GEOLOGICAL SURVEY

OF

CANADA.

REPORT OF PROGRESS

FOR THE YEAR 1857.

Printed by Order of the Legislative Assembly.

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1858.

GEOLOGICAL SURVEY OF CANADA.

MONTREAL, 31*st March*, 1858.

SIR,

I have the honor to request that you will do me the favor to present to His Excellency the Governor General the accompanying Report of the progress made in the Geological Survey of the Province during the year 1857.

I have the honor to be,

Sir,

Your most obedient servant,

W. E. LOGAN.

To the Hon. T. J. J. Loranger,

Provincial Secretary,

Toronto.

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FOR 1857.

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TO HIS EXCELLENCY

SIR EDMUND WALKER HEAD, BART

ONE OF HER MAJESTY'S MOST HONORABLE PRIVY COUNCIL,

Governor-General of British North America,

AND

CAPTAIN-GENERAL AND GOVERNOR-IN-CHIEF

IN AND OVER

THE PROVINCES OF CANADA, NOVA SCOTIA, NEW BRUNSWICK, AND THE ISLAND OF PRINCE EDWARD,

AND VICE-ADMIRAL OF THE SAME.

MONTREAL, 31st *March*, 1858.

MAY IT PLEASE YOUR EXCELLENCY:

I have the honor to present to Your Excellency a statement of the progress made in the Geological Survey of the Province during the past year; and in doing so, to place before you the Reports of those gentlemen who have aided me in the investigation committed to my charge. The Reports are those of Mr. Murray, Mr. Richardson, Mr. Bell, Mr. Billings, Professor James Hall of Albany, Mr. Hunt, and Lieut. E. D. Ashe of Quebec.

The labors of Mr. Murray comprised in the first place a topographical measurement and geological examination of the coast and the immediately adjacent islands at the mouths of the French River, the object of the work being to complete his surveys of the various branches of that river by shewing their relation to that part of Georgian Bay into which they fall. When the delineation of this portion of Mr. Murray's work was received in Montreal the plans of his various previous

surveys of the river were in the hands of the lithographer to be engraved, as part of the Report last presented to the Legislature, and ordered to be printed under my direction. With the view of obviating the expense of an additional map to accompany the present Report, the delineation was introduced in its appropriate place on the plans then in progress, and it appears as part of the Report for 1856, while the geographical and geological descriptions constitute a portion of what is now submitted to Your Excellency.

Another duty assigned to Mr. Murray was the investigation of the physical structure of the copper-bearing rocks of Lake Huron. The economical importance of these rocks authorises a more detailed examination than there has yet been any opportunity of devoting to them. The discovery of the copper-lodes by which they are characterised is of course, the main object to be held in view; but to search for these by mere empirical examination, without any fixed rule, would be an endless work. The metalliferous lodes of any formation are found for the most part in cracks or dislocations which have disturbed the formation, and which have given an opportunity for the secretion of the ore. One set of positions in which such disturbances may be expected is the axes of anticlinal and synclinal folds; whence it becomes of importance to know where these folds exist. The best way of determining this is to ascertain the geographical distribution of the constituent parts of the formation, and the figure they exhibit when represented on a map. But in a stratified formation like the Huronian, the beds having a general conformity one to another, if the distribution of one bed be ascertained it will give an extensive knowledge of that of the remainder; it therefore becomes of great use to select one well-marked band of the formation and to follow it out. In about the middle of the Huronian series there is a conspicuous band of limestone from 150 to 250 feet thick, which is so completely contrasted with the rest of the formation in aspect and mineral character that it was considered the best to select for examination, as a test of physical structure, and Mr. Murray was instructed to trace it out.

The position selected by Mr. Murray from which to commence his examination was Echo Lake. The original map which accompanied this part of Mr. Murray's work is protracted by Mr. Johnson on the scale of one mile to one inch. But for the purposes of this Report it has been reduced to a smaller scale, and there has been added to it the position previously ascertained of the same band of limestone on the Thessalon River and on the coast immediately west of the Bruce mine, as well as its position on the Bruce mine location, in which last place it was pointed out to Mr. Murray by Mr. Borron, the superintendant of the mine. The relation of the different parts of the band, so far, will thus be understood in a general way, though it will still be necessary to ascertain the details of the intermediate parts, in order properly to connect the work around Echo Lake with that on the Thessalon River.

The want of conformity heretofore pointed out, between the Upper and Lower Silurian rocks of the Gaspé peninsula, prevents the out-crop of the one group from being any guide to the distribution of the other. At the same time both series of rocks are very much corrugated. From the neighborhood of the Chaudière to the Rivers Chatte and St. Ann, the axes of the folds appear to run nearly north-east, but they then change to east, and subsequently to south-east; and an irregularity occurs in the out-crop of the superior rocks, which, in attempting to construct a geological map of the peninsula, it was found impossible to represent with any approach to truth without a special examination of the interior between the St. Ann River and Gaspé Bay. Mr. Richardson was in consequence instructed to ascend the River Magdalen, and on reaching the out-crop of the Upper Silurian series, to follow it out to the right and the left. He has done so to the eastward, so as to join his work with what was done in Gaspé Bay by myself in 1843. But the season was so far spent by the time he returned to the Magdalen, that it would have been hazardous to attempt to join his work with that of Mr. Murray and myself to the westward. For this another opportunity must be chosen.

Mr. Richardson subsequently ascended the Saguenay for the

purpose of making a *reconnaisance* of Lake St. John, preliminary to whatever future examination might be prosecuted in that neighborhood; and I have to draw Your Excellency's attention to the very favorable report he furnishes of the climate and agricultural capabilities of the valley of that lake, and the apparently great extent of land there capable of prosperous settlement.

Mr. Richardson's Report is accompanied with a plan of the Magdalen River on the scale of one mile to one inch, that which has usually been adopted for all our measured surveys, as well as one on a smaller scale, shewing the distribution of the rocks traced out in the Gaspé district, and another giving that of the Lower Silurian strata met with on Lake St. John. The plans are the work of Mr. Scott Barlow, who accompanied Mr. Richardson on his explorations.

Mr. Richardson was accompanied also by Mr. R. Bell, who in addition to aiding in the general work of the exploration, was instructed to make a collection of the recent marine, fresh-water and land shells he might meet with, as well as such other objects of natural history as could be obtained and transported without interfering with the main objects of the investigation. Mr. Bell has furnished a Report enumerating the species and localities of his collection, which will be of utility in aiding us to a knowledge of the geographical distribution of such organic forms. In transmitting this to Your Excellency I have to express my obligations to Mr. Lea of Philadelphia, one of the highest authorities in this department of natural history, for the aid he has kindly given in naming the land and fresh-water species of the collection, three of which he regards as new.

In addition to his labors in the arrangements of the Museum, the attention of Mr. Billings has been devoted to various points connected with the distribution of the Lower Silurian limestones on the Bonne-chère, the Upper Silurian limestone of Galt, and the Devonian rocks of the western peninsula of Upper Canada. His Report on these, together with his descriptions of various new species of organic remains, is now transmitted to Your Excellency.

Several new species of the genus *Graptolithus*, with others of *Dictyonema*, discovered by Mr. Richardson in the vicinity of Quebec in 1854 and 1855, were then placed for examination and description in the hands of Professor James Hall of Albany, whose works on the palæontology of North American rocks are too well known to require mention. These organic remains he kindly undertook to have figured and engraved, as a contribution to the palæontology of Canada; and his Report on the progress made in the work, with his descriptions of the fossils, constitutes one of the documents connected with the present communication.

The Report of Mr. Hunt comprises researches on the nature and mode of formation of magnesian limestones, farther investigations of some traps, serpentines and mineral waters, and some observations upon the value of the artificial guano manufactured from the fish-offal and bituminous shales of the Lower St. Lawrence.

My own time has been largely employed in the arrangements of the Museum. The cases designed to hold the collection of the Survey were not completed until after my return in 1856 from the Paris Exhibition; and my intention was that my assistants, when they should have completed the study and comparison of the facts and materials of each summer's exploration, should devote their remaining time to the classification and distribution of the specimens of the collection, until this task should be accomplished. But the American Association for the Advancement of Science having accepted a joint invitation from the Mayor and Corporation and the Natural History Society of Montreal, to hold their annual meeting for 1857 in this city, it became in some degree imperative upon the officers of the Survey at once to place the Provincial collection illustrative of Canadian Geology in a condition to be fully appreciated by such men of science, devoted to this branch of investigation, as might be present at the meeting. To do this required the whole of Mr. Billings' time, and very nearly the whole of my own, until the meeting of the Association which took place on the 15th of August.

Among the eminent men of science present at the meeting of the Association, I was glad to welcome my distinguished friend Mr. A. Ramsay, deputed to represent for the occasion the Geological Society of London. Under Sir Roderick Murchison as chief, he directs the Geological Survey of Great Britain, and is at the same time one of the Professors of the Government School of Mines; and I felt persuaded that it would greatly conduce to the benefit of Canadian geology, and serve to extend the interest already existing in it in the United Kingdom, if Professor Ramsay could be induced to accompany me, after the business of the Association should be concluded, on a geological tour through a part of the Province. An arrangement to this end was made, and Professor Hall volunteering to be our guide through the classic geological ground of New York, which I had never previously visited, I deemed it advisable to take advantage of so favorable an opportunity for increasing my own experience, and for making me acquainted with some of the Devonian rocks of that State which appear to be wanting in the Canadian series.

The requirements of the meeting of the American Association, and the few weeks spent in the tour to which I have alluded, brought round the month of October before I could enter upon any personal explorations. These were devoted to a farther investigation of the crystalline limestones of the Laurentian series of rocks, in which something has been added to our knowledge of their geographical distribution; but as no facts have been ascertained to illustrate their sequence beyond what were presented in the Report of 1856, and as a continued prosecution of the investigation is intended during the ensuing season, it appears to me desirable to reserve a farther description until I am furnished with a larger number of new facts.

While the arrangements effected in the Museum have so much trenched upon the time usually devoted to field work, they have placed the Survey in a position to more readily compare and understand the value of the materials from time to time collected, to decide at once upon what may be considered duplicates, and to commence a distribution of them

among the educational institutions of the country. This was one of the objects originally contemplated in the institution of the Survey, and a first instalment of specimens has been sent to University College, Toronto, and Laval University, Quebec.

In the last Report it was stated that in carrying into effect that portion of the duties assigned to me which regarded the determination of the longitudes and latitudes of important places in the Province, I had had recourse to the use of the telegraphic wire for the longitudes, and had availed myself of the services of Lieut. E. D. Ashe of the Quebec Observatory. I have now the honor of transmitting to Your Excellency Lieut. Ashe's Report, with an abstract of the work done up to the present time. By this it will be observed that the longitudes determined are those of Quebec, Montreal, Ottawa, Kingston, Toronto, Collingwood, Windsor and Chicago. Quebec was made the point of departure in Canada, and the longitude of Quebec has through the kind assistance of Professor Bond, been compared with that of Cambridge Observatory near Boston, which is considered the position on the continent of America whose relation has been most accurately determined with Greenwich.

The determination of these various positions has enabled me to give a general truth to the topographical map of Canada, on which I am to delineate its geology. This map is now nearly completed, and would long ere this have been in the hands of the engraver, had not about half the time of the draughtsman who is compiling it been unavoidably occupied in preparing the tracings for the lithographer, and correcting the proofs of the twenty-two sheets of plans which have just been printed for the Legislature in connection with the last Report of Progress.

I have the honor to be

Your Excellency's most obedient servant,

W. E. LOGAN.

REPORT,

FOR THE YEAR 1857,

OF

ALEX. MURRAY, Esq., ASSISTANT PROVINCIAL GEOLOGIST,

ADDRESSED TO

SIR WILLIAM E. LOGAN, F.R.S.,
DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

MONTREAL, 1857.

SIR,

In the spring of the present year you were pleased to direct me to make a topographical measurement of the coast of Georgian Bay, where the several mouths of the French River discharge themselves, in order to connect the surveys previously made of the various branches of that river.

For this purpose, after having provided myself with two canoes, an assistant, and a party of Indians at She-bah-ah-nah-ning, I repaired to Pointe des Grondines, where our labors commenced about the middle of June. Being favored with very fine weather for carrying on our operations, little time was lost in accomplishing the work, and I had the honor of forwarding to you in July a plan of the same, with all particulars recorded on it. This work, I have understood from you, was received in time to be incorporated in the map of

my previous explorations then in course of being lithographed, on the face of which it has already been published.

In accordance with your farther instructions, I then proceeded with my party to Bruce Mines, and subsequently to Echo Lake, near the western extremity of Lake Huron, where you suggested I should commence to work out the physical structure of the copper-bearing or Huronian rocks of the region, by following up the remarkable band of limestone which is there well developed about the middle of the formation. In connection with this work a survey was made of Echo Lake and River, the north part of Great Lake George, the connecting stream of St. Mary between Great and Little Lakes George, Little Lake George and a part of Garden River. From various points of this survey cross-bearings were constantly taken upon all the most conspicuous features in the interior. By these we were enabled to fix the position of such points with tolerable accuracy, and they afterwards rendered us good service as checks upon the perambulated measurements made during our inland excursions.

Through the aid of my assistant, Mr. John Johnston, who acted chiefly as draughtsman on the occasion, a plan of this portion of our work was completed on the usual scale of one inch to one mile. It represents all the main topographical features of the country examined, with its geology where it could be satisfactorily ascertained, and is accompanied by a vertical section. These have already been placed in your hands, and I would beg to call your attention to the very creditable manner in which Mr. Johnston's work is executed.

Finally, I made a short excursion from Bruce Mines for the purpose of ascertaining with accuracy the position of the out-crop of a band of limestone reported to me by Mr. Borron, the superintendant of the mine there, as having been observed a short distance from the works and within the location, and no doubt identical with that mentioned above. The connection of this work with the previous, cannot with certainty be shewn until some further intermediate examinations have been made, which I hope to accomplish in the course of the ensuing season's operations.

COAST AT THE MOUTHS OF THE FRENCH RIVER.

Geographical Characteristics.

The waters of the French River are discharged into Georgian Bay through several channels between Pointe des Grondines on the west and the inlet called by Bayfield the Key, which is situated at the north-east angle of Lake Huron. The distance between these two positions is a little under eighteen miles, and they are nearly due east and west of one another. The outlets of the river may be divided into three sets, the western, the middle and the eastern. Each set is composed of several discharging branches, every one of which before reaching the surface of Lake Huron is precipitated over a fall or rapid. The country is by this complicated reticulation cut up for many miles between the main body of the river and Lake Huron, into a great group of islands.

The western outlets have two main channels, the old travelled channel and the Mauvaise Rivière. The old travelled channel enters Lake Huron by three branches of discharge, which are situated about six miles from Pointe des Grondines in a bearing a little north of east. The middle of these branches has for many years been the principal ingress and egress for the Hudson Bay Company's canoes to and from their posts on the Ottawa, Lake Nipissing, and other parts of the interior. It is the one most easily approached from without, as well as most easily navigated.

The Mauvaise Rivière is situated about seven and a-half miles from Pointe des Grondines, and it also empties into Lake Huron by three branches, all within a short distance of one another, and each having a fall of about four feet, before joining the still water of Georgian Bay.

The middle outlets or Large River channel fall into the bay through three openings. The most western is about three and a-half miles east from the Mauvaise Rivière; the other two, which are small and within a-quarter of a mile of each other, are about a mile and a-half farther east, or about thirteen miles from the Pointe des Grondines.

The eastern outlets consist of two openings which empty into a long narrow bay lying directly north of the Hudson Bay Company's old post at the mouth of the Key inlet.

All these channels and outlets flow through a barren and desolate waste. The greater part of it is either perfectly bare rock, or a surface made little better than such by a scanty covering at intervals of small stunted trees and bushes, chiefly belonging to varieties of the fir tribe. The country is for the most part low, but extremely rugged, offering bold and precipitous but not very lofty cliffs on the coast, while the surface is arranged in sharp and broken ridges of rock, parallel to one another, for the most part in a north-east bearing, and conforming to the bays and outlets.

Innumerable islands, islets, knobs and reefs of rock lie off this part of the coast, rendering an approach to it dangerous and difficult at all points, but most especially off the entrance to the middle outlets or Large River channel. Between this and the cluster of islands called the Bustards, situated from two to three miles to the southward, nothing can be safely navigated larger than a canoe or a boat of the smallest draught of water. The old travelled channel or eastern set of outlets is undoubtedly the most accessible part for any craft, but there are many reefs and sunken rocks between it and the Pointe des Grondines, over which the swell of the lake may be distinctly heard to break for many miles around.

As an agricultural country a large portion of the region immediately south of the chief part of the French River appears to be valueless, and the pine-timber, where it attains a size worthy of notice at all, is too much scattered, and besides usually too small to be of any commercial importance. The principal if not the only recommendation which the coast at present possesses is as a fishing station. In this respect it is equal to any other part of the lake. It is amply supplied with white-fish and trout, as well as bass, pike and pickerel, all of which are now taken in large quantities by the Indians and half-breed fishermen from Weh-que-mi-kong and She-bah-ah-nah-ning; and were the trade skilfully and systematically pursued by an establishment possessed of capital, it would not fail to be a source of considerable profit.

Distribution of the Rocks.

The rocks of this part of the coast and of the islands adjacent to it are all of the Laurentian age. They consist of red and grey hornblendic and micaceous gneiss, becoming frequently very schistose, of quartzite, and intrusive masses of syenite and greenstone, intersected by veins of white quartz and cut by dykes of granite. The general strike of the stratification varies from a few degrees east of north to about north-east, the inclination being usually south-eastward at high angles. The strata are arranged in a series of parallel ridges, which alternate with low narrow valleys or with numerous channels or indentations of the coast. They are usually more or less contorted, and undulations of considerable magnitude may occasionally be observed in some parts. An example of such an undulation exists between the middle and eastward outlets, and it suggests the probability that there are frequent repetitions of the same strata.

A great mass of syenite, of coarse grain for the most part, sometimes reddish, but chiefly grey in color, spreads over the country between the western and middle outlets. The gneiss at the Mauvaise Rivière dips towards the syenite as if passing beneath it, while that near the middle outlets, where seen in contact with the syenite, dips from it about S. E. $<80^{\circ}$.* The surface of the syenite is very low and flat, and almost destitute of vegetation; that of the gneiss presents abrupt broken ridges, more or less covered with a small growth of ever-greens and deciduous bushes. At the entrance to the bay receiving the discharge of the middle outlets, the gneiss is intersected by dykes of greenstone, and both are cut by granite veins.

Portions of the gneiss are garnetiferous, especially among the hornblendic schists and quartzose bands. These portions were observed chiefly near the extremes of the part surveyed, that is, near Pointe des Grondines on the one hand, and in the

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* The bearings given in this Report are magnetic, the variation being about $4^{\circ}\ 15'$ W. at the mouths of the French River, and about $0^{\circ}\ 30'$ W. in the neighborhood of Echo Lake.

bays that intervene between the middle and eastern outlets on the other.

Quartz veins are of frequent occurrence throughout the whole region; many of them are of large size, but in no case were they observed to contain any mineral indications worthy of especial notice, nor have any rumours through the Indians or others reached me of the presence of metalliferous lodes nearer than Lake Nipissing.

The character of the rocks here is not usually very well adapted for building purposes, except of the most ordinary description. The hard beds are usually thin, and they alternate with crumbling schistose layers, which are frequently contorted or broken. From such strata it would scarcely be possible to procure any available materials, but when the harder beds are of tolerable thickness and the strata somewhat regular, they might be made available, especially when they happen, as they sometimes do, to be cut by parallel joints in directions at right angles to one another. This is the case in the south part of the bay receiving the discharge of the middle outlets.

Portions of the syenite would no doubt dress into handsome rectangular blocks, and make a durable and elegant material, but the working of it would be attended with considerable difficulty, for the rock is tough and hard to cut or blast, and it does not appear to possess any regular joints either horizontal or vertical, though it would probably split in any direction required by the application of plugs and feathers.

It is probable that should stone be wanted for facing any public work in this region the nearest and best supply will be found among the Niagara limestones of the Grand Manitoulin Island. From them too would be obtained the lime required for the purpose of mortar.

ECHO LAKE AND THE SURROUNDING COUNTRY.

Geographical Characteristics.

Echo Lake is beautifully situated among lofty hills and bold precipitous rocks, a little over three miles north-east

from the head of Great Lake George, with which it is connected by a sluggish stream flowing for the greater part through marsh or low flat land. The length of the lake is about four miles from head to foot, in a line running north-east and south-west. Its breadth is contracted by two opposite points of limestone near the middle, to a distance of somewhat under a mile, while it opens above and below into expanding bays. The widest part of the upper expansion is about two miles, and that of the lower rather less than a mile and a-half.

The main stream, supplying the lake with water, comes in at the north-east angle of the upper expansion through a marsh. Above the marsh the stream becomes rapid, and its upward course bears nearly due east for about three miles. It then bends round to the south-eastward. The valley continues in this direction for several miles, but finally turns to the westward and north-westward, and opens into a prairie with a small lake which constitutes the head of the stream.

The two Lakes George and the connecting stream between them are bounded by Sugar Island on the one side and the Canadian mainland on the other. The distance from the mouth of Echo River at the head of Great Lake George, to Root River at the head of Little Lake George, is seven miles and a-half in a straight line bearing west-north-west. The banks on either side of the stream on this line are low and flat, and frequently marshy ; but at a short distance back, on the north side, the surface becomes broken and mountainous, rising in abrupt rocky precipices or bold rugged hills, and affording frequent scenes of great and picturesque beauty.

On the south in Sugar Island the land rises gradually to a considerable elevation, and presents a gently undulating surface, contrasting strongly with the wild and rugged character of the mountainous region on the north.

At the foot of Little Lake George, Garden River falls in on the left bank. Its course near the outlet is exceedingly tortuous, but the valley has a general upward bearing of about N. N. E. as far as we ascended it, which in a straight line, did not exceed three miles. I was informed by the Indians that

the stream was accessible for canoes for many miles farther up, but that it became very rapid and difficult to navigate above the highest part we reached.

To the east of Echo Lake, and northward of the limestone point on the east side, there is a tract of fine land, heavily timbered with maple, elm and birch, interspersed at intervals with groves of hemlock and a few pines, with cedars in the hollows and swamps. The surface of this part rises gradually to the south-eastward for upwards of two miles, and is beautifully watered by numerous little brooks falling into the lake. This tract extends northward to the valley of Echo River, and is bounded to the eastward by a small brook which falls into the river where its upward bearing turns to the south-east, which is about two miles and a-half from Echo Lake.

To the east of this tract, and to the south of it and of the lower expansion of Echo Lake, the country is rugged and broken. It is marked by a succession of precipitous hills and narrow valleys, which run nearly due east in the south part, but take a south-easterly course as they advance. Among these ranges the waters of a considerable area flow westerly into the lower part of Echo River or Lake George. One of the streams flowing into the former has a nearly due east upward bearing for about three miles, where it is the outlet of a beautiful lake about four miles long, in a south-easterly bearing, divided into two nearly equal parts about a mile wide each where broadest, connected by a gut not exceeding a couple of chains in breadth.

On the north-east side of the upper part of Echo River bold precipitous cliffs rise up to heights of 500 feet; as they approach the north shore of Echo Lake they strike westward and run inland beyond the lake in the same direction, in conformity with the parallel ridges on the south already mentioned.

Westward of Echo Lake, and between it and the valley of Garden River, the country is very much broken by rocky ridges, but there are intervals of beautiful hard-wood land in the hollows and lower parts between them. Through each of these valleys there usually flows a pretty brook of clear

water, taking its rise from one or other of the picturesque little lakes which lie on each side of the water-shed. Between Garden River and Root River, at a distance of from one to two miles from the north shore of St. Mary River and Little Lake George, a similarly rugged description of country prevails, with intervals of hard-wood land, lying at a high elevation, and at such parts the principal trees being hard maple, it is much frequented by the Indians for the manufacture of sugar.

The plains that skirt the main river and the shores of the Lakes George on the north side are possessed of a light sandy soil yielding red pine of good size, with a profuse growth of wild fruit trees and bushes; but there is also a great extent of marsh-land, where wild grass or reeds constitute the chief part of the vegetation.

Character and Distribution of the Rocks.

Huronian Series.—The rock formations examined in the region around Echo Lake are altogether of the Huronian age, with the exception of the flat parts skirting the shores of Great and Little Lakes George and St. Mary River. These, with Sugar Island, although nowhere exhibiting a good exposure of the rock in place, very probably belong to the lower members of the unconformable Silurian strata. To follow out the structure of the altered and contorted Huronian series, a band of limestone belonging to it was selected as the best developed feature, and the one most readily recognisable from its peculiarities of mineral character, as well as its association with a remarkable conglomerate both above and below.

The two points at the narrow part of Echo Lake are composed of this limestone, and the band was followed with little interruption to the westward, from the point on the west side of the lake, until it was found to sink below the plain in the valley of Root River. At the point on the west side of Echo Lake the dip is southerly, and freed from minor contortions it shews an average inclination of about twenty-five degrees; but the strike almost immediately inland turns off about north-west, and the limestone forms the face of the high cliffs west

of the bay on the north side of the point. The band then trends about west by north for nearly three miles, after which it sweeps round and runs in a south-easterly direction for about two miles, giving evidence of a synclinal form in the stratification. It then folds over an anticlinal axis, making a sharp turn to the west, running in that direction with a southerly dip. Following the band on the south side of the anticlinal, it keeps a general course nearly parallel with the valley of the main river, and it is seen largely developed on the high land on each side of Garden River. Again it appears on the high land about a mile and a-half back from the head of Little Lake George, near the valley of Root River, beyond which in the same direction, we have the flat country underlaid by the Silurian strata.

This calcareous portion of the Huronian formation averages about 200 feet in thickness. It presents alternate layers of pale blue or whitish limestone, and greenish calcareous and silicious slate usually in thin strata. The calcareo-silicious slate weathers out in high relief, and gives a striped or ribbon-like aspect to the mass when exposed. About the middle of the band there is a calcareous breccia, generally in a massive bed, holding angular fragments of greenstone trap and dark blue or blackish impalpable grained slate.

Both above and below the limestone the rock is a slate conglomerate, the base of which is usually of a greenish color, frequently having the aspect of an igneous rock; but it contains numerous rounded pebbles of various kinds, the chief part of which are syenite, quartz, gneiss and jasper. In some cases the conglomerate is very coarse, the pebbles or boulders as they may be called, forming the greater part of the mass. In other cases the rock is a fine compact slate, enclosing rounded masses of various sizes and characters, which are scattered through the slate at wide distances from one another.

Following the limestone band east from Echo Lake, it strikes about E. S. E., and is lost beneath the heavily timbered land in a little more than half-a-mile from the point. It forms in this distance two rather sharp-ridged hills, with a northerly escarp-

ment to each, and they are flanked to the east by a cedar swamp. Beyond this the band was nowhere found in place for five miles; but it appears by the distribution of the upper and lower conglomerates, which were traceable for the greater part of six miles, and by occasional loose limestone blocks between them, that it runs in prairies and marshy valleys where the rock is altogether concealed. The general strike of the conglomerates is south-easterly, parallel with the ridges which have been already described; and in the position to which this would carry the calcareous band, blocks of limestone were met with a little over half-a-mile south-west from the exit of the small lake at the head of Echo River, from which position it is probable that it holds the same course until it strikes Thessalon and Otter-tail Lakes on the Thessalon River, where it is already known to be exposed.

The rocks beneath the lower slate conglomerate are greenish silicious slate and pale greenish quartzite, which on Echo Lake are displayed in high precipitous cliffs on the north side. These are underlaid by greenstone, and below the greenstone is a highly altered green chloritic slate, which is exposed in nearly vertical strata forming high precipices at the extreme head of the lake.

Above the upper slate conglomerate there was observed at several places a thinly laminated dark blue or blackish slate of very fine texture, interstratified with thin beds of dark grey quartzite. These were overlaid by whitish or pale grey quartzite, in some parts immediately succeeded by a mass of greenstone, and in others gradually passing upwards into a quartzose conglomerate with blood-red jasper pebbles.

Great masses of trap appear to be irregularly interposed among the strata. They are of nearly uniform character, being for the greater part coarse grained greenstone of a dark green color. Numerous greenstone dykes intersect the formation, which seem almost invariably to be fine grained or compact. About two miles north of Root River a deep flesh-red granite dyke of a porphyritic character occurs. It is interposed between the lower chloritic slates and an overlying mass of greenstone, which runs nearly parallel with the strike of the stratification.

A line drawn in a north-east and south-west direction near the centre of the area examined, as represented on the map, would cross the measures at about a right angle, and they would probably be found to be as follows in ascending order :

	Feet.
1. Green altered slates of a chloritic character, ...	1000
2. Greenstone, ...	400
3. Greenish silicious slates, interstratified with pale greenish quartzite,	1200
4. Slate conglomerate, ...	1000
5. Limestone, ...	250
6. Slate conglomerate, ...	800
7. Dark blue or blackish fine grained slates, with dark grey quartzite,.	500
8. Whitish or whitish-grey quartzite, passing into quartzose conglomerate with blood-red jasper pebbles, ...	1000
9. Greenstone, ...	700
	6850

Copper pyrites is very generally disseminated through the masses of greenstone wherever they were examined, and it occasionally appears in quartz veins in sufficient abundance to constitute metalliferous lodes. The most favorable indications known of this description in the area are on the south side of Echo Lake, and in the hills north of the mouth of Root River, both of which localities have been taken up for the purposes of mining, but have not hitherto been worked to advantage.

Specular iron ore was also frequently observed both in the trap and in the sedimentary portion of the formation, occasionally arranged in thin continuous layers between the strata for considerable distances, and at other times in small isolated masses irregularly distributed through the rock. The latter condition was especially observed in the quartzose conglomerates with blood-red jaspers, where indeed the iron ore appeared to constitute a characteristic mineral.

Portions of the band of limestone are available in an economic point of view for burning into quick-lime, but it is not in general well adapted for building stones. Mr. Palmer of Sugar Island informed me that he had procured a few loads of the stone for the purpose of testing its capabilities, and

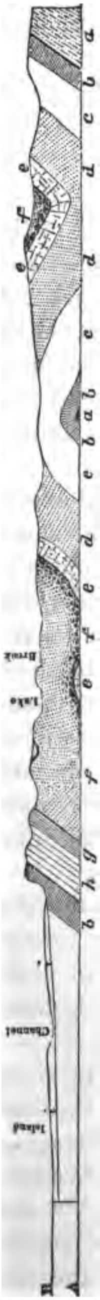
found it to produce an excellent material for mortar, although rather difficult to burn, and mostly of a dark color.

Lower Silurian Rocks.—On the north end of Sugar Island, and the flat land contiguous to it north of Little and Great Lakes George, no exposures of rock were found, with the exception of certain strata in the valley of Garden River. Here a shale or indurated clay occasionally crops out at the lower part of the bank of that tributary, and is of a reddish color, sometimes mottled with green spots or marked with green stripes. A red color similar to that of the shale is pretty generally imparted to the clay and soil of all the flat land in the country around, and slabs and fragments of red or variegated red and green sandstone are imbedded in the clay and distributed largely over the surface.

A rock similar to the fragments of sandstone is found extensively displayed in place at Sault St. Mary, and there cannot be much doubt that the red shale of Garden River belongs to the same set of strata, and that these strata run under the Lower Silurian limestones which occur farther south on St. Joseph Island. In so far as the Canadian portion of these limestones is concerned, I am not aware that any of the fossils which have been brought from them are characteristic of deposits older than the Chazy limestone; and the total absence of fossils from the red sandstones makes it difficult to determine exactly their equivalent in that part of the Lower Silurian series which is inferior to the Chazy.

Drift.—The whole of Sugar Island and the flat land at the foot of the Huronian hills, including the lower part of the valleys which run up among them, is covered with deposits of clay, sand and gravel, with numerous boulders derived chiefly from the copper-bearing rocks to the north.

The banks of Garden River, which are from forty to sixty feet high, are composed of red and drab clays holding calcareous concretionary nodules, and surmounted by a stratum averaging about six feet in thickness of coarse sand of a reddish-yellow color. The flat land on the north side of River St. Mary and its two lakes, as well as the margin of Sugar Island, is largely composed of sand and gravel presenting the ruins of the red



A, Level of Sea. B, Level of Lake Huron.

a, Green chloritic slates.
b, Greenstone.
c, Greenish silicious slates, with bands of quartzite.
d, Lower slate conglomerate.
e, Limestone.
f, Upper slate conglomerate.
g, Fine-grained black or dark grey slates.
h, Whitish and grey quartzite.
i, Lower Silurian red and green sandstones.

sandstone formation, mixed up with those of greenstone, quartzite, and various shales of the Huronian series. The boulders are in general derived from the latter formation, and among them are conspicuously displayed, particularly to the south of the point more especially examined, immense blocks of red jasper conglomerate; but at one part near the out-crop of the Huronian limestone at Root River there are numerous large rounded masses of gneiss and mica slate, resembling in all respects such as are derived from the Laurentian rocks. A large mass indeed was observed, which had the appearance of being in place. This is situated in a ravine, north of the limestone, between the lower slate conglomerate and a band of greenstone trap overlying the green silico-chloritic slates; it forms a low escarpment, much covered and concealed with bushes, and consists of red and grey micaceous gneiss, in alternating bands, with a dip N. E. <35°.

The rocks in the neighborhood of Echo Lake present many smooth rounded surfaces, shewing ice grooves and scratches. The direction of those that come under my observation varied from S. 55° W. to S. 70° W.

The accompanying wood-cut represents a vertical section of the rocks on the line drawn on the map a little to the west of Echo Lake.

The scale of the section is one mile to one inch, both horizontally and vertically.


GEOLOGICAL SURVEY OF CANADA.
Sir W.E. Logan F.R.S. Director.
PLAN
SHOWING THE DISTRIBUTION OF THE
HURONIAN LIMESTONE
BETWEEN
ROOT RIVER AND BRUCE MINES
Scale of Statute Miles
Thessalon Lake
Limestone
Otter-tail Lake
Thessalon River
LOCATIONS
Mr Cameron's Lot
Supposed outcrop of Limestone
Point Thessalon

Huronian Limestone near the Bruce Mine.

The information derived from Mr. Borron regarding the out-crop of the band of Huronian limestone on the Bruce mine location, was found to be essentially correct. The limestone occurs in small broken ridges about half-a-mile or a little more north from the lake shore, and a short distance east from the boundary between that location and the next to the westward, in the occupation of the Wellington Mining Company. Its general aspect and mineral character are identical in most respects with those displayed by it elsewhere. It is much disturbed and intersected by dykes of greenstone trap, the general bearing of the principal of which is about N. 72° W. and S. 72° E.

The position of the limestone here and at the most southern point of the next location westward, where its presence is stated in your Report on the North Shore of Lake Huron in 1848, indicates the structure you then appear to have suspected as the true one for this part of the coast. These exposures of the calcareous band are on the opposite sides of an anticlinal axis, and between the newly discovered out-crop and the developments of the band on Thessalon and Otter-tail Lakes, north of the location, there is a synclinal form, on the axis of which the band will turn somewhere southward of the lowest exposures which we observed together on the Thessalon River.

I have the honor to be,

Sir,

Your most obedient servant,

ALEX. MURRAY.

REPORT,

FOR THE YEAR 1857,

OF

MR. JAMES RICHARDSON, EXPLORER,

ADDRESSED TO

SIR WILLIAM E. LOGAN, F.R.S.,

DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

MONTREAL, 31*st December*, 1857.

SIR,

In the month of May last you were pleased to direct me to make a geological examination of a part of the Peninsula of Gaspé. I was instructed to commence with a survey of the Magdalen River, and from it to trace the out-crops of such important groups of rock as might be met with to the eastward as far as Gaspé Bay.

Leaving Montreal on the 26th of May, I arrived at Quebec the next day with my party. Here a week elapsed before a proper conveyance could be procured, and two more weeks were occupied by our passage down the St. Lawrence.

Having arrived at the mouth of the Magdalen, a few days were spent in making arrangements for the survey of the river. We commenced by measuring a part of the coast below its mouth, and in determining our distances both here and subsequently on the river, we made use of the micrometer telescope, while our bearings were ascertained by prismatic compass.

In these operations I was aided by Mr. Scott Barlow, who being at one end of the sights while I was at the other, was enabled to check the bearings; and having with us a repeating circle and reflecting horizon, I was farther indebted to Mr. Barlow for a general check on the measurements, by his frequently ascertaining the latitude by observations of the sun. Mr. Robert Bell, another of our party, in addition to a persevering attention to the general objects of the survey, devoted a part of his time to the collection of recent objects of natural history, his observations on which will be communicated to you by himself.

Our ascent of the river commenced on the 20th of June, and the highest point on it to which our micrometer measurements reached, being the farthest navigable for our canoes, was attained on the 20th of July, the distance being over sixty-two miles. A farther distance of a few miles was examined on foot, but running short of provisions, we were obliged to return to the mouth of the river. For several days previous to our return we subsisted principally on porcupines, which we found in some abundance along the river.

After allowing the men a few days rest we again ascended the river twenty miles, and then leaving our canoes, made a traverse southward, nearly at right angles to the stratification, to York River, which empties into the south-west arm of Gaspé Bay. From this we proceeded eastward, nearly with the stratification, until we struck the Dartmouth River, intersecting it near its discharge into the north-west arm of the bay. When about half-way, Mr. Barlow separated from us to run a line of section oblique to the measures, striking the Magdalen where we had left it, and to take our canoes back to the mouth.

Another traverse was made from Griffon Cove on the St. Lawrence to Peninsula Cove in Gaspé Bay; and proceeding thence up the Dartmouth River to the west line of South Sydenham township, an additional transverse line was measured from this position to Grand Etang on the St. Lawrence.

The whole distance, with the exception of the sixty-two miles on the Magdalen, was travelled on foot, and all our

perambulations, comprehending over a hundred miles, were measured by counting our paces, positions being checked as occasion occurred by bearings on previously determined prominent objects.

On leaving the Magdalen my intention was to return by the York River to the point where we struck it on our first traverse, and then to cross over to our starting point; but the want of sufficient water in this stream for its navigation in canoes, forced me reluctantly to abandon the attempt, and purchasing a boat at Grand Etang we ascended the St. Lawrence to the mouth of the Magdalen.

There being scarcely sufficient time again to ascend the Magdalen with a view of tracing the out-crops by a pedestrian excursion to the westward, and so join our work with that of Mr. Murray on the St. Ann in 1845, and your own on the Chatte in 1844, I was tempted by the facility of navigation to make an excursion up the Saguenay to Chicoutimi, and thence to Lake St. John. The examination here made can only be considered preliminary to such future explorations as you may institute upon the various important streams that flow into this lake, and the distribution of the rock masses on its borders will require the exploration of some of these rivers to be made intelligible.

Leaving Lake St. John, Mr. Bell and our canoe-men returned by steamboat from Chicoutimi down the Saguenay to Tadousac, and thence to Quebec, while Mr. Barlow and myself made our way on foot by the road to Bay St. Paul; thence we proceeded to Quebec, and there joining the remainder of the party, two days after they had arrived, we reached Montreal in the beginning of November.

Description of the Magdalen River.

The Magdalen River falls into the St. Lawrence on the south side, in latitude 49° 15′ 32″ N. and longitude 65° 18′ 36″ W. nearly. Its mouth is about sixty miles above Cape Rosier, and about seventy below Cape Chatte. The entrance to it from the sea is on the west side of a not very deep bay, from

which the right or east bank of the river is separated for about a mile by a narrow strip of fine gravel, but little elevated above the highest tides, while the left bank consists of an escarpment of stratified clay, about ninety feet in height, containing marine shells of the drift period. This escarpment continues out about a-quarter of a mile beyond the mouth of the river, and, resting on black bituminous shale, forms Cape Magdalen. It extends up the coast for between two and three miles, and the clay of which it is composed spreading for about a mile or a mile and a-half inland, presents a gently undulating surface, well fitted for cultivation. Some patches of grain upon it, consisting of wheat, rye and barley, appeared to promise a fair average yield, and others of potatoes and turnips seemed to be in a thriving condition, though the style of husbandry was but indifferent.

From the mouth of the river to the highest part reached by us, the distance in a straight line about S. W. is but thirty-one miles and a-half, while following the sinuosities of the stream it is sixty miles, and the distance actually measured by micrometer is 62 miles 2 chains 65 links.

The first stretch of the valley from the mouth of the river to Porcupine Bluff, (so called from our having killed the first porcupine upon its top,) is about eleven miles, but the channel of the stream measures very nearly fourteen, the general upward bearing being S. 25° E.* In this a serious impediment is met with in the ascent of the river about five miles from its mouth. It consists of two vertical cascades of twelve and sixty-two feet respectively, with a torrent above and between, occurring in a narrow precipitous gorge, with banks so steep as to be impassable, and rising to the height of 800 or 900 feet on each side of the stream. Over the summit of this height, on the eastern side, it became necessary for us to effect a portage, and the difficulties in transporting our canoes across were so great that seven days were consumed in the task, though the

* The bearings given in this Report are in relation to true north. The variation in the area of the Gaspé exploration is about 2[illegible]° 0′ W., and in the valley of Lake St. John about 18° 30′ W.

distance was not much over a mile. Not only had we to cut a clear road through very thickly growing though not large spruce trees, but after the road was opened we were obliged to use ropes, and to hold on by the trees in ascending and descending the hill, as well as to excavate foot-holes with a shovel to avoid slipping.

In flowing through this gorge the stream makes a turn out of the general bearing of about half-a-mile to the westward, its course presenting rudely three sides of a parallelogram, below which the valley continues narrow to the flat land at the mouth, while the hills rise irregularly on either bank to heights not much inferior to that of the portage. Above the portage the valley is less deep and somewhat wider, the land presenting a more gradual fall from the hills, the sides of which appear to be but thinly covered with soil, while coarse gravel composes such flats as are met with at the foot. The timber on the flats consists of balsam-fir, white birch and cedar, with now and then ash and elm, but the last two are by no means abundant, while the mountain sides, all the way up from the sea, present balsam-fir, spruce, white birch and pine, the last being in some abundance about the portage.

For the next four and a-half miles above Porcupine Bluff the general upward bearing of the valley is a little west of south, in which the stream measures rather over six miles and a-quarter, to the junction of a tributary falling in on the right bank; to this from its temperature, in the absence of any known name, we gave that of Cold Water Brook. This tributary was the first of any importance met with; it comes from the south through a valley which is a continuation of that of the Magdalen up to this point, and just before joining the Magdalen, it flows between two prominent mountains, for which their shape suggested the appellation of East and West Terrace Mountains. On their north sides, particularly that of the west mountain, and towards the top, several perpendicular escarpments of from fifty to a hundred feet each, rise at irregular distances behind one another, and sweeping round into the valley of the Cold Water branch they slope to the south and converge, gradually becoming less marked, until they disappear

altogether. By a rough measurement the summit of the eastern mountain was computed to be 1375 feet above the river, or 1957 feet above the sea. The summit of the other, about a mile to the westward, was not ascertained by measurement, but it is probably about 200 feet higher.

The soil and timber above Porcupine Bluff differ but little from those below, with the exception of an increasing abundance of white pine. It appears to me probable that between the portage and the Terrace Mountains about one-sixth of the wood seen on the slopes was of this species; most of it is large enough for saw-logs, and some may be of a size fit for squared timber. How far back from the river it may extend I am not prepared to say; but even what was in view would in my opinion, be worthy the attention of lumberers. The only difficulty in getting it out would be the falls and rapids near the portage, but these might probably be improved, while they would afford unlimited water-power for mills. From the foot of the falls sawn timber might be sent with safety to the mouth, where there is a good harbour, and deep water for two vessels, while over the bar at the entrance, there is a depth of seventeen feet at the ebb of tide.

From the Terrace Mountains the upward course turns nearly west and continues so for very nearly five miles, presenting a succession of rapids, with a swift current the whole way. On the south side, West Terrace Mountain is continued for half the distance, but after the first mile it loses in elevation. On the north, for the same distance, the hills come close upon the river, presenting a height of about 500 feet. In the remainder of the distance the hills on both sides are more detached and less elevated.

The next stretch of the valley runs N. 25° W., and in this bearing, which continues for six miles, it presents a parallelism with that part between Porcupine Bluff and the mouth. The hills on each side are farther apart than those lower down, and not so bold, the highest summits not exceeding 500 feet over the river. Just at the turn at the upper end of this part of the valley a tributary falls in on the left side; at its immediate junction it is twelve feet wide, and its downward

course south; but as it appears probable that it issues from a small lake, the position of which was described to me by one of the inhabitants at the mouth of the Magdalen, the general downward course of the depression in which it runs, may be about south-west. In this case it would be a continuation of the next and longest stretch of the valley of the main stream, and would apparently correspond with the depression on the south side of the portage mountain.

The next and longest stretch of the Magdalen valley has an upward bearing of about S. 55° W., and in this bearing a straight line of nearly twenty-four miles brings us to the end of our micrometer measurements. In this part of the valley the only marked divergence from the bearing given is about six miles up, where the general course is nearly west for about two miles. The lower end of this divergence is marked by a tributary fifteen feet wide, which flows in on the right, and another half-a-mile above it, and twenty-four feet wide, falls in on the left, while the right side two miles still farther up presents an additional branch. This is twenty-eight feet wide, and its transparency suggested the name of Clear Water Brook. The only other branch of any importance in the twenty-four miles also falls in on the right, about three miles below the termination of our micrometer measurements; at its mouth it was thirty feet wide.

The hills along each side of this stretch of the valley, although not so high over the bed of the river as those lower down, are more regular in their outline. They run in ridges parallel to one another. Those nearest the river, which are at no great distance, appear to be between 200 and 300 feet high, and those visible farther back gain upon them but slightly in elevation. These ridges appear to agree in their direction with the general course of the river, with the exception of one on the right side, the escarpment of which is seen three miles east of the Clear Water, and just south of the bend mentioned, at the junction of the lowest tributary. Facing the north, this escarpment rises rapidly to a height of probably 700 feet, and the surface then sloping more gently in a contrary direction, gives the aspect of an isolated hill.

The escarpment resembles the north side of East Terrace Mountain, and bearing exactly for the position of that mountain, it is probably of the same formation.

From the Terrace Mountains upwards the timber of the valley is smaller than lower down. It consists of spruce, balsam-fir, white birch and cedar. Only a few trees of white pine were observed. The soil is thin both on the hills and on the flats. On the latter it is supported generally on coarse gravel, in which pebbles of reddish syenite abound. These pebbles were small at the lowest point at which they were observed, but appeared gradually to increase in size as we ascended, and towards the end of our measurements the river found its way with a rapid current among large rounded masses of this rock. The masses much resemble some of the syenites of the Laurentian formation, and may have been transported from the north side of the St. Lawrence.

About a mile and a-quarter above the termination of our measurements a large tributary joins the main stream on the left. The valley in which it flows is not deep, and can be traced by the eye in its upward course, which is N. 25° W., for between nine and ten miles. For a mile above its junction, with an average breadth of forty feet, it presents a rapid and broken stream, and probably runs with a swift current the whole distance. Beyond this, according to the description given me by a hunter well acquainted with this part of the country, its upward course turns west of south, and in about four miles reaches the base of a mountain which rises considerably above the table-land through which it flows; it is in several small lakes or ponds on the summit of this mountain, about two miles farther, that the tributary has its source.

About a hundred paces farther up the main stream than the mouth of the north branch a tributary enters on the opposite side, shewing a breadth of about ten feet. It runs in a depression which appears to be a continuation of the previous one, its upward bearing being S. 10° E. The main stream from the end of our measurement to the junction has a breadth of from sixty to eighty feet, and its upward bearing is S. 70° W. or nearly at right angles to the two branches. This upward bearing

it maintains until it reaches the base of the same mountain that gives origin to the north branch, the distance being about five miles. From this, as described to me by the hunter already mentioned, it bends round the southern base of this mountain, making an arc to which the last mentioned bearing of the main stream, if produced, would form a chord of five miles more, with a distance of about a mile and a-half from the curve about half-way. From the western extremity of the chord the upward course is about north for three miles, when by a sharp bend it becomes east for about four more, the main valley splitting up into several subordinate depressions, each of which sends a contribution from one or more small lakes at its source. These lakes are scattered among the tops of the same mountain in which originates the north branch, and the more southern of them are not far from its source, while the more eastern are not over one or two miles from the east end of the curve made by the main stream round the mountain's base.

This mountain rises boldly above the general level of the country around, its summits attaining a higher elevation by probably 1000 or 1500 feet. Approaching it, the size of the forest trees appear to diminish considerably, and occasional open spaces produce only short wiry grass. The sides of the mountain seem almost devoid of trees, and the top destitute of all vegetation whatever. Large areas below the summit appeared to be covered with huge detached masses of grey-colored rock, and some parts were marked with stripes of red, while on the 20th of July along the whole length of the upper surface, as seen from the mouths of the north and south branches of the river, patches of snow were abundant. In a bearing parallel with the depression or valley of these branches the measure of the mountain is about ten miles. According to Mr. Murray, the St. Ann River flows in a wide valley between Mount Albert of his exploration of 1845 and this mountain, which would therefore from a favorable point of view, appear to be a great isolated hill, and it evidently constitutes the abrupt eastern termination of the Shick-Shock range of mountains, which from the Matan, where Mr. Murray places its western limit, would thus have a length of about sixty-five miles.

While we ascended the Magdalen an endeavor was made to determine the rise of the valley. The river is so rapid in the whole of its length that we met with scarcely any reaches of smooth water to aid us in carrying forward ascertained levels from one part to another; and as we had no mountain barometer, it would have been necessary, in order to attain any reliable result, to use a spirit-level the whole of the way. We did not consider it prudent to expend upon the task the time this would have required. I contented myself therefore with measuring by means of the spirit-level of my clinometer the rise of only the more precipitous parts, and estimated others by the comparative aspect of the current, and the greater or less resistance offered to the progress of our canoes. With the exception of two short intervals, in which the canoemen could use their paddles, they were compelled to resort to their poles the whole distance, or jumping out into the water to drag or push the canoes along with their hands. On such occasions we were often obliged to land and scramble along the bank for considerable distances, and it was then I could sometimes ascertain the rise of parts by the clinometer. The result is given for what it is worth, without any great confidence in its accuracy, except as a very rude approximation to the truth.

Levels of the Magdalen River.

	Distance.	*Rise.*	*Total Distance.*	*Height above the Sea.*
	M. Ch. L.	Feet.	M. Ch. L.	Feet.
Rise from the mouth up the river to high-water mark,...............	1·59·48		1·59·48	
—— from high-water mark to the foot of the first rapid, estimated at 9 feet per mile,..................	1·57·55	15·4		
—— from the foot of the first rapid to the foot of the Mountain Portage, including a measured rise of 14·5 feet in 28 chains, estimated at 20 feet per mile,..................	1·20·74	25·0	4·57·77	40·4
—— from the foot to the head of the Mountain Portage, viz. :—				
Rapids, including two vertical falls of 3 feet each,..(measured) 19·5	0·25·12			

	Distance. M. Ch. L.	Rise. Feet.	Total Distance. M. Ch. L.	Height above the Sea. Feet.
Cascade, ...(measured) 12·0				
Torrent between the Cascades, (measured) 131·6	1·02·81			
Cascade, ... " 62·0				
Torrent to the head of Mountain Portage,...(measured) 82·5				
——	0·21·76	307·6	6·27·46	348·0
Rise in continuous rapids above the head of the Mountain Portage (measured)	0·55·93	43·5		
—— from the head of the previous rapids to a cascade, broken water all the way, estimated at 20 feet per mile, ...	0·51·14	12·7		
—— in a cascade, ...(measured)		4·0		
—— from the head of the cascade to Porcupine Bluff, swift current all the way, estimated at 12 feet per mile, ...	6·22·30	75·3	13·76·88	483·5
—— from Porcupine Bluff to Terrace Mountain Rapids at Cold Water Brook, a swift current all the way, the last half being broken water, estimated at 15 feet per mile, ...	6·49·22	99·2	20·46·05	582·7
—— in part of Terrace Mountain Rapids, (measured)	3·21·41	283·5		
—— in continuation of Terrace Mountain Rapids, terminating 20 chains above a small brook joining on the right, estimated at 45 feet per mile,.....	2·36·48	110·5	26·23·94	976·7
—— from the head of Terrace Mountain Rapids to the foot of Flat Rapids, a strong current with comparatively smooth water the whole way, estimated at 5 feet per mile,.........	0·46·05	2·9		
—— in part of Flat Rapids, (measured)	0·74·87	65·0		
—— in continuation of Flat Rapids to a tributary joining on the left side, at the Great Elbow, estimated at 30 feet per mile, ...	3·20·67	97·7	31·05·53	1142·3
—— from the head of Flat Rapids to the foot of Red Rapids, a violent current all the way, often breaking into rapids, estimated at 15 feet per mile, ...	5·33·69	81·3		
—— in Red Rapids, estimated at 25 feet per mile, ...	0·73·64	23·0		

	Distance.	Rise.	Total Distance.	Height above the Sea.
	M. Ch. L.	Feet.	M. Ch. L.	Feet.
Rise from the head of Red Rapids to a tributary joining on the right, a violent current all the way, often breaking into rapids, estimated at 15 feet per mile,.................	3·59·50	56·1	41·12·36	1302·7
—— in rapids to a tributary joining on the left,..............(measured)	0·66·95	28·0	41·79·31	1330·7
—— from the head of the last rapids to the foot of Clear Water Rapids, a violent current with much broken water prevailing all the way, estimated at 15 feet per mile,........	3·68·07	57·7		
—— in Clear Water Rapids to Clear Water Brook, estimated at 70 feet per mile,......................	0·36·02	31·5	46·23·40	1419·9
—— from the head of Clear Water Rapids to the foot of Long Rapids, a violent current all the way, with much occasionally broken water, estimated at 15 feet per mile,......	10·02·10	150·3		
—— in Long Rapids to the end of micrometer measurements, estimated at 70 feet per mile,..............	5·37·84	383·0		
—— from the end of micrometer measurements to the junction of North and South Branches, rapids similar to the last prevailing all the way, estimated at 70 feet per mile, ...	1·20·00	87·5	63·03·34	2040·7

This would give for the valley a rise of about thirty-two feet in a mile; but if from the result be deducted the Mountain Portage cascades and rapids, and the measured part of the Terrace Mountain Rapids, both of which are perfect torrents, the rate of rise would be reduced to about twenty-five feet in a mile. On the St. Ann, though Mr. Murray met with no vertical falls, he ascertained by barometrical measurement that the rise in the part which he measured, was about twenty feet in a mile, and from the description he gives me of its navigation I am induced to suppose that his difficulties of ascent were by no means equal to ours, even when those of the Mountain Portage and Terrace Mountain Rapids are excluded. The rise given to the Magdalen therefore does not appear extravagant.

Taking the height of the valley at the north and south branches to be 2000 feet, and that of the mountain between the Magdalen and the St. Ann to be 1500 more, its summit would be 3500 feet above the level of the sea. Mr. Murray's barometrical measurement of Mount Albert made its summit 3778 feet above the sea; and as he states that when standing on Mount Albert, the mountain to the east of St. Ann River bounded his view in that direction, it would follow that its height must have been at least equal to his own elevation, which would correspond nearly with the conclusion arrived at by myself.

District between Magdalen River and Gaspé Bay.

The distance from the mouth of Cold Water Brook to York River where we struck it on our traverse, is nearly eleven miles in a straight line, bearing S. 25° E. We followed the valley of the Cold Water, which bends more to the west, but our greatest distance from the straight line was not over a mile and a-half. It occurred when we had proceeded up the brook about three miles and a-half, where a tributary ten feet wide joins it on the right, with an upward bearing south of east. From this the bearing of the Cold Water valley again gradually approaches the straight line, and about a mile and a-quarter farther up another tributary joins on the same side as the former, and runs nearly parallel with it. A third falls in about three-quarters of a mile farther, on the opposite side; and the source of the main brook is met with about three miles and a-half above it. The source consists of a great multitude of copious springs which issue over an area of from thirty to forty acres, and collecting together form at once a considerable stream.

These springs were on the highest ground of our traverse, and were estimated to be about 800 feet above the Magdalen at the junction, which would be nearly 1400 feet above the sea. Immediately beyond them the descent to the York River commenced, the distance to the river being about two miles and a-half, to which there was a fall of probably 800 feet.

In the valley of the Cold Water as in that of the Magdalen there is evidence of a thin soil. The timber up to the first brook is spruce, balsam-fir and cedar, and there are large areas both on the mountain sides and in the lower parts of the valley, where the trees appear from the slightness of their hold in the ground, to have fallen over into a confused net-work of prostrate timber, through which a subsequent dense growth has sprung, producing a tangled mass very difficult to penetrate. The trees above the first brook are of the same kind as those below, but they are small, generally from two to three inches in diameter. The woods are open however, and afford good walking, and there is evidence of a previous growth having been destroyed by fire. Although pine was rarely met with standing, the charred and prostrate remains of good-sized trees, were by no means scarce.

From the position where we struck the York River to the settlements on the north-west arm of Gaspé Bay, the distance in a straight line about east, is thirty miles, but the line we travelled was about five miles more. The position at which Mr. Barlow separated from us, which we called the Ponds, was about eleven miles forward on this line, and his traverse to the Magdalen, in which he kept a straight line N. 63° W., was seventeen miles and a-half.

In the first part of our eastern traverse we kept along the left bank of the York River for about three miles. The width of the stream was from a chain and a-half to two chains; its current was rather swift, and its surface shewed broken water in several places. Its banks were often abrupt, presenting bare precipices of calcareous rock varying in height from fifty to 200 feet. In the three miles that we walked along its left bank we crossed three considerable tributaries with a general north-westerly upward bearing; they joined the main stream through rocky precipitous gorges of from 200 to 300 feet deep. Below the last one, the river gains rapidly to the southward, in its downward course, being turned in that direction by an elevation of from 300 to 500 feet, in which considerable vertical breaks of rock are brought to view.

This elevation forms a ridge which divides the York River

from one we met with at the distance of four miles from the last of the tributaries mentioned. We supposed it to be the upper part of the Dartmouth River. It was twenty-four feet wide where we crossed it, and it flowed north. In its upward bearing it appeared soon to turn eastward, and farther in that direction it probably occupies the next valley north from the York River, and runs parallel with that river for some distance, but in a contrary direction. About two miles and a-half exactly north from our point of intersection, Mr. Barlow crossed it on his return traverse. It was there still flowing north, but it probably turns to the east not far below, to gain the position where I subsequently left it at the north-west corner of South Sydenham township, and the point where our eastward traverse previously came out upon it, two miles farther down.

Proceeding on our eastern traverse, only two other streams of any importance were met with, and they were both tributaries of the Dartmouth. One of them occurred about nine miles from our first intersection of the main stream. It had a breadth of twenty-four feet, and flowing northward, it must join the Dartmouth some short distance above the west line of South Sydenham. The other was met with three and a-half miles farther east. It goes among the settlers on Gaspé Bay by the name of Lady-steps Brook. Where we crossed it its breadth was twenty feet, and its flow was from the south-west, in which direction its source is probably near that of the main stream. On our course it occupied a deep gorge, with a considerable mountain on the west and a still more important one on the east. The latter may have a height over the bed of the stream of probably 1200 or 1300 feet, and we gave it the name of Mount Serpentine, from the fact of our having discovered on it a band of serpentine, which we traced for a distance of nearly a mile and a-half. The stream turns eastward along the northern base of this hill, and joins the main river about three miles below our crossing.

Between York River and this brook the inequalities of the surface did not appear to be many. One occurred three miles east of our first intersection of the Dartmouth. Here an

escarpment of from fifty to a hundred feet of shaly limestone, facing the south-west, capped an elevation of from 300 to 400 feet, passing over which we descended as much in about a mile and a-half to the Ponds already mentioned as the position where Mr. Barlow commenced his return traverse. The rills on each side of this ridge flowed southward to the Dartmouth. The next four and a-half miles, to the north-flowing brook already mentioned, are indented with no more than a gorge or two of from eighty to a hundred feet deep, but in a mile beyond the brook we ascended 700 feet and kept at that height for a mile and three-quarters, and then descended from 800 to 900 feet in a-quarter of a mile farther. This descent is within three-quarters of a mile of Lady-steps Brook, and thus constitutes the flank of the mountain already mentioned as existing west of it.

East of Mount Serpentine our way to the settlements of Gaspé Bay was marked to the right by a bold range of heights rising 1500 feet or more above the sea, cut by occasional transverse gorges, while on the left we had the valley of the Dartmouth at no great distance.

On our eastern traverse the timber met with consisted chiefly of balsam-fir, tamarack and cedar. On the first part of the line it appeared to be small, but it increased in size when we came to within fifteen miles of Gaspé Bay. In damp bottoms cedars were occasionally met with measuring ten feet in circumference. Pine was not observed until we were within eight miles of the settled part. The most marketable portion of it seemed to have been cut down by the lumberers several years ago, and what now remains appears to be of but little importance.

Ascending the Dartmouth River from its mouth, the first nine miles, up to Lady-steps Brook, run nearly on the strike of the rocks, and though the stream is rapid and broken, it is navigable for canoes. For two miles above this it runs across the measures coming from the north, and the lowest half-mile of the distance is characterised by several vertical falls, varying from two to ten feet in height. Beyond these two miles a zigzag upward course for four miles more is sometimes with and

sometimes across the stratification, and reaches to the west line of South Sydenham township. This was as far as we continuously ascended the stream, but its course beyond has already been indicated.

A little above the South Sydenham line the river is joined by a tributary coming from the north across the stratification. It is eighteen feet wide at its mouth, which constituted the starting point for our traverse to Grand Etang. Several tributary brooks and rills, running in deep dells oblique to the stratification, flow into this one on each side, and crossing these in succession, the inequalities of the surface appear more marked on this traverse than on the east one further south, but there did not appear any important difference in the soil or timber.

The traverse from Griffon Cove to Peninsula Cove was made on the new road in the course of construction by the Government. In this part there is generally a better soil and larger timber than I met with in any other locality visited. Considerable areas support a heavy growth of yellow birch and maple, with varieties of ash and elm, promising in this instance at least, fertility to the agriculturist.

DISTRIBUTION OF THE ROCK FORMATIONS.

The rocks met with in the district of which the geographical features have just been given, are similar to those which in previous Reports have been described by yourself and Mr. Murray, as prevailing both to the east and the west of the area subjected to my examination. I shall give their characteristics as they appeared to me, in the order of their supposed ascending sequence, as established by yourself, not only from the results of those explorations, but in regard to part of the series, as modified by your subsequent examination of the vicinity of Quebec, and the facts ascertained last year on the Island of Anticosti. The Gaspé district is so disturbed that without reference to previous investigations, it would have been impossible for me to have arrived at correct conclusions in respect to superposition, more particularly with regard to the members of those subordinate groups which constitute the two lower divisions of its rocks.

By the arrangement in the museum of the Survey, of the specimens previously obtained on the north side of the Gaspé peninsula, I am made aware that the great groups to which the rocks of my last season's exploration on the south side of the St. Lawrence belong are—

1. Lower Silurian.
2. Middle Silurian.
3. Upper Silurian.
4. Devonian.

In previous Reports the fourth division was termed the Gaspé sandstones, the third the Gaspé limestones and shales. The second and first were separated into a series entitled conglomerate limestones, pillar sandstones and graptolitic shales, and was described under seven subordinate groups, some of which it was supposed might be repetitions of one another, the true sequence not having been determined. The Quebec and Anticosti examinations lead to the conclusion that the ascending sequence of the Lower and Middle Silurian rocks of Gaspé under the titles above mentioned is—

A, Graptolitic shales.	} Lower Silurian.
B, Conglomerate limestones.	}
C, Pillar sandstones.	Middle Silurian.

In the geology of New York A and B are members of the Hudson River group, A having been occasionally called the Lorraine shales, and B, Eaton's sparry limestone; C is supposed to be equivalent to the Oneida conglomerate. In the geology of Canada A has been locally termed the Richelieu shales, B the Quebec or Point Lévy conglomerate limestones, and C the Sillery sandstones. With this explanation I shall proceed to describe the distribution of the rock formations in the area between the Magdalen River and Gaspé Bay.

Section between Griffon Cove and Peninsula Cove.

Commencing with the most eastern traverse, that between Griffon Cove and Peninsula Cove, you have yourself already

stated that the coast exhibits a great exposure of hard black brittle shale holding graptolites, the thickness of which may be about 1000 feet. These shales belong to the group A, in the first or lowest great division.

Two miles south-westward of the cove, about an-eighth of a mile is covered with large angular fragments of a greenish sandstone, some of which presented the aspect of a fine conglomerate with quartz pebbles as large as peas. All the fragments tried were more or less slightly calcareous. None of the rock was seen in place, but the abundance and angularity of the fragments convinced me that it could not be far removed, and the position of the fragments may be assumed as that of the rock. These sandstones resemble those of Sillery and would thus belong to group C, or the second great division. Between their position and that of the coast exposure there would be ample room for group B.

Half-a-mile or more beyond this, loose fragments of black slate and a grey slightly calcareous sandstone covered the bed of a brook in great abundance, and occurred not far from a post marked "Lots 3 and 4," being no doubt the corner post common to those lots in the township of Gaspé, but in what range I was not able to ascertain. These fragments resembled some of the strata of Point Lévy, and are therefore supposed to belong to group B.

Beyond this brook a mile and a-quarter, the position being about five miles from Griffon Cove, large masses of a conglomerate rock cover the surface for a short distance. They were traced in undiminished abundance for 200 paces to the westward, and not quite so far to the east, leaving no doubt they were close upon the position of the rock *in situ*, and indicated its strike, which would be about S. 40° E. and N. 40° W. The loose masses shewed the rock to be an aggregate of quartz pebbles of about an inch in diameter, most of which are white, with others of grey compact limestone, of yellowish-white feldspar and of green shale. The matrix was greenish and strongly calcareous, and the color of the weathered surfaces reddish-white. This conglomerate is coarser than any part I have seen of group C, but the pebbles and color of the fragments appear

to me to be more closely allied to the strata of this group than to those of B.

A-quarter of a mile still further on, we come to the base of the third great division, or the Gaspé limestones and shales. The first exposure on the Griffon Cove road occurs in a brook called by the inhabitants Ruisseau de la Grande Carrière, where about forty-five feet of grey limestone are seen. The greater part of the beds is composed of very pure limestone, which would be an excellent material for burning into lime; but these pure beds are interstratified with others of an arenaceous character, which on exposure to the weather decompose into a porous earth to the depth of half-an-inch. These strata are overlaid by beds which by the action of atmospheric waters, lose their lime on the exterior, and give a light porous chalk-white residue. Nodules and patches of chert occur in these beds, which also weather white with a slight tinge of yellow. These forty-five feet of strata contain moderately well preserved fossils, among which were *Atrypa reticularis*, *Strophomena depressa*, *Favosites Gothlandica*, and encrinal stems. The dip of the beds in the Ruisseau de la Grande Carrière is S. 54° W. <20°, and a mile and a-quarter forward across the measures, in another brook a few beds of iron-grey limestone shew a dip of S. 4° W. <22°. It is probable that these exposures with the interval between them comprehend the whole thickness of the Gaspé limestones, for the more southern one strikes the foot of a hill presenting a flank which runs to Little Gaspé Cove, where as you have stated, the junction of this and the succeeding formation can be seen. An average of the dips mentioned would give a thickness to this calcareous group of 2100 feet, which very well corresponds with that stated in your Report, as the thickness farther east.

From the foot of the limestone hill to the margin of Gaspé Bay below Peninsula Cove the distance is about a mile and a-half. In this the only exposure of rock seen occurred at ninety-six chains forward. It consisted of greenish-grey sandstones, without fossils, shewing a dip S. 29° W. <39°, and judging from the rocks which strike out upon the coast farther down the bay, there is little doubt the whole distance from the

hill is underlaid by strata of the same character. This would give a thickness of about 4000 feet, which is the thickness you assign to this portion of the Gaspé sandstones in your Report, stating that it constitutes one side of a synclinal form, and is repeated with a contrary dip on the other side of the bay.

Section from Grand Etang to the Valley of the Dartmouth.

Between high and low water-mark on the coast and up the stream issuing from the lake or great pond which gives name to the place, a wide exposure exists, as you have yourself stated, of black bitumino-argillaceous shales interstratified with grey calcareous sandstones, and thin grey yellow-weathering limestones, marked with graptolites in the shales, on some of the limestones, and the surfaces of the more arenaceous layers. The breadth displayed by these strata approaches half-a-mile, and their dip is very uniform in a direction S. 20° W.; but the slope varies from thirty degrees on the south side to seventy degrees on the north, and between the two there is supposed to exist an anticlinal axis, similar to several examples displayed in the neighbouring cliffs. On the north side of the axis the thickness of the strata is computed to be about 1400 feet, and they are supposed to belong to the group A of the first or lowest division. These beds are not so black nor so bituminous as those at Griffon Cove, and though they are supposed to belong to the same group, and may in fact represent them, they are presumed to be partially beneath them.

Upwards of two miles southward from these beds the next exposure met with occurs. It consists of greenish-grey slightly calcareous sandstone, weathering brownish. In parts it approaches the character of a fine conglomerate, with translucent quartz grains in some abundance, and small flat pieces of black shale, with occasional flakes of silvery mica. The beds are from twelve to fifteen inches thick, and are divided by cleavage joints into natural rectangular prisms of various lengths. The stone would dress easily, and is of sufficient toughness to retain its edges and corners; it would constitute a good material for building purposes. The width of the

exposure was thirty paces, and the strata were vertical, with a strike S. 89° W. The aspect of the rock somewhat resembles the sandstones of the group C; but evidence derived from exposures farther south, to be mentioned presently, induced me to suppose that its place was in the group B.

Beyond these sandstones no exposures were met with for a mile and a-quarter. There then occurred black and iron-grey shales, alternating irregularly with black and green shales, both interstratified with greenish-grey yellowish-weathering limestone beds from an inch to an inch and a-half thick. Beds of this character crop out at intervals for another mile and a-quarter, the dip of the most southern exposure being S. 10° W. <51°. Comparing these beds with your description of some of the shales associated with the conglomerate limestones between the St. Ann and Chatte Rivers, they also are supposed to belong to group B.

Immediately succeeding these, and prevailing for a mile and a-half, are greenish-grey sandstones interstratified with red shales, of which shales there appears to be an important band at the base on the north side. There were exposures of these rocks both in the brook which ran near the line of traverse and in the neighbouring heights, and their resemblance to the Sillery sandstones leaves no doubt in my mind that they belong to group C. The dip of the northern portion was S. 10° W. <51°, and of the southern S. 6° W. <64°. The latter is probably an overturn, for from the evidence farther on, the form of the deposit must be that of a trough. The distance from the most southern exposure of these strata to the Dartmouth, near the western line of South Sydenham township, is about a mile, and it is not improbable that the formation may extend to the vicinity of the river.

Farther south than the south-west corner of South Sydenham, but somewhat to the east, there occurs an exposure of rock in the bed of the Dartmouth. It consists of a somewhat coarse grained sandstone, one bed of which was twelve feet thick, and composed of an aggregation of laminæ of not more than one-eighth of an inch each; these when separated, shew on the surfaces a thin film of a nacreous aspect, which might be taken

for talc. These beds are associated with greyish nacreo-silicious slates, and thin calcareous layers, and with them present nearly throughout a set of minute wrinkles. They are also traversed in various directions by strings and small veins, some consisting of white quartz and others of calc-spar. Similar rocks occur two miles farther down the river, and are so contorted that it is difficult to follow the relation of one part to another.

About half-a-mile further down the stream, the channel of it is strewed in abundance with great fragments of conglomerate, the pebbles of which consist of light grey compact limestone, varying in diameter from one to three inches, aggregated so closely as to afford but little room for the matrix, which is itself sufficiently calcareous to be called a limestone, though of an arenaceous character. On the exterior the fragments weather to a yellowish-brown, and in their whole aspect they very much resemble the conglomerate limestones of Point Lévy. The abundance of the fragments leaves little doubt that though the rock from which they were derived was not seen in place, it could not be far removed. A little lower on the river there is an exposure of greenish-grey calcareous sandstone so strongly resembling in every particular that mentioned as occurring nearer the coast, that specimens from the two localities cannot be distinguished from one another, and the near proximity of the conglomerate limestones in the present instance induces the supposition that these sandstones in both cases belong to group B.

The position of the last mentioned exposure is about a mile and a-half above the junction of Lady-steps Brook with the Dartmouth, and it is immediately followed by a considerable developement of the Gaspé limestones. The two formations are not seen in contact, and it appears probable that a fault of some importance may run between them, as the beds in the lowest display of the limestones are much disturbed, while the whole volume of the formation appears to be suddenly thrown forward to the south more than two miles by an upthrow on the west side. A mile and three-quarters of the distance, (being the breadth of the space between the eastward traverse and

the upward examination of the Dartmouth,) were not travelled over, and I cannot therefore state with certainty the character of the rocks that may be exposed in them. It is probable however, that they continue to belong to group B; for on the north side of Lady-steps Brook rises Mount Serpentine, the rock giving the name to which is supposed here as in the Eastern Townships to appertain to this group. This serpentine is situated about half-a-mile on the south side of the brook, and about 800 feet above its channel. It occurs in a band which was traced for upwards of a mile running S. 82° E.; but from the precipitous fall of the cliff in which it was exposed it was difficult to ascertain its exact breadth. As near as it could be made out at three places it was estimated at between thirty and forty paces. The rock is a blackish-green interiorly, weathering brownish-red on the exterior, and like the Silurian serpentines of the Eastern Townships it has been found by the analysis of Mr. Hunt to contain both chromium and nickel. In contact with the serpentine on the south side dark green chlorite slate occurs, and appears to occupy the breadth of perhaps half-a-mile, rising to the summit of the hill, which may be 500 feet over the serpentine. The strike is given above, but it was not possible to determine on which side the slope occurred. The opposite side of the hill was not examined, but it is probable another half-mile would intervene before reaching the Gaspé limestones.

The following is an ascending section of the Gaspé limestones as they are seen on the Dartmouth on the east side of the fault:—

	Feet.
Grey limestone of a uniform compact texture in beds of from one to six inches thick, which are much disturbed, the beds for short distances standing in various attitudes, both as regards strike and inclination; an allowance of one-half the apparent volume is made for the irregularities,..	83
Measures concealed,..	465
Grey limestone of compact and uniform texture, in regular beds of from one to six inches thick; dip S. 9° W. <20°,....................	81
Measures concealed,..	223
Grey arenaceous limestone with a few obscure fossils; nodules and small patches of chert prevail in the lower part, while the upper beds are of a uniform grey compact limestone as before,..........	429

	Feet.
Grey compact limestone in beds of from one to six inches thick, in thin close laminæ. The rock weathers to a chalk-white porous mass without lime, for an inch on the surface, ...	137
Measures not well examined in consequence of the steep and difficult character of the side of the gorge through which the river passes,.	503
Grey hard calcareous beds with very fine lines of lamination; the rock weathers white and yellow, ...	121
	2042

The following is a section in ascending series of the Gaspé sandstones, seen in contact with the limestones:—

	Feet.
Iron-grey fine grained argillo-calcareous sandstones with small scales of silvery mica in the planes of bedding, and carbonized comminuted remains of plants in abundance. Interstratified with the sandstones are occasional beds of grey limestone from a-quarter of an inch to an inch thick, weathering yellowish-brown, and containing encrinal columns, obscure corals and bivalve shells,......	95
Greenish-grey sandstones, in beds of from one to six inches thick, with ripple-mark on some of the surfaces, as well as comminuted remains of plants in abundance. A few thin beds of grey limestone are interstratified, but no fossils were observed in them,.........	552
Greenish-grey sandstone, with comminuted remains of plants, interstratified with iron-grey and greenish shale, and a few hard grey calcareous beds. The dip is S. 4° W. <41°. The position of this exposure is on the left bank of Lady-steps Brook, at its entrance into the Dartmouth,......................................	357
	1004

Section of the Magdalen River.

As already stated, Cape Magdalen about a-quarter of a mile north of the mouth of the river on the west side, is composed of drift clay with marine shells such as at present inhabit the gulf, resting on black shales. This clay occupies the left bank for about a mile and a-quarter above the mouth. The black shales beneath are interstratified with grey calcareous sandstones, and they are visible from the cape to the mouth of the river, dipping S. 3° E.< from 32° to 60°, the high angle which is at the cape being probably an overturn dip. On the river, for a mile and a-quarter up, no strata are visible, but on the coast about a mile to the eastward there are great exposures, the strike of which would bring the strata into the upper

three-quarters of a mile. These are composed of black shales interstratified with thin hard grey calcareous sandstones, and grey limestones more or less arenaceous, sometimes the shales and sometimes the harder beds predominating. They present towards the base two coarse grained calcareous sandstone beds about ninety feet apart and about fifty feet thick each, holding fossils. Among these could be recognised *Leptæna sericea* and *Orthis testudinaria*, both of them however slightly distorted by molecular movements in the rock; an *Orthoceras* accompanied them. The general dip of these measures is about S. 3° E. < from 25° to 30°, and the thickness upwards of 1000 feet. These beds are probably in part a repetition of those at the cape, though it is not easy to point out the exact position of any fold connecting the two.

Measures more or less of the same general character, with the exception of the strong coarse grained fossiliferous sandstones, prevail for the distance of five miles more up the valley, comprehending the rocks of the Mountain Portage and of the rapids for a mile and a-quarter above, and it is supposed probable that they are carried forward thus far by repetitions resulting from undulations, the evidences of which however it is not easy to detect. The first exposure occurs immediately beyond the position assigned to the shales already described. The dip is S. 4° E. <52°, and this inclination is so much steeper than that of the previous dip, that it may be taken for an overturn. The next exposure is three-quarters of a mile farther up, and the succeeding one another three-quarters of a mile beyond, where the dip is S. 4° W. <54°. Three-quarters of a mile still farther a small synclinal and anticlinal are visible, keeping the strata at the surface for some distance. Within half-a-mile farther, at the foot of the portage and at the foot of the twelve-feet cascade a short distance above, the average dip is S. 6° E. <63°, and there are displayed grey argillaceo-calcareous slates with thin beds of a compact yellow-weathering black dolomite, which shews itself also in nodules or patches of from three to four feet in thickness, with an obscure separation from the enclosing rock. Some of the nodules measuring from six to fifteen inches in diameter are of a grey

color. Thin beds of this yellow-weathering black dolomite mark the strata to the head of the portage, and the measures seem to be arranged in the form of a trough. The strike varies a few degrees now and then, but the dip with a southerly direction first shews an inclination of $<59^{\circ}$, then $<36^{\circ}$. It then becomes northerly, with an inclination of $<85^{\circ}$, which it maintains to the sixty-two-feet fall, but at the head of the portage it is reduced to $<5^{\circ}$. Here there is a distinct difference between the bedding and the cleavage, and the layers of dolomite are included in grey strongly calcareous slates, weathering white, striped with black bands which give a dark brown streak, though they emit no bituminous odour when rubbed or freshly fractured.

In the additional mile above the portage the strata in the lower exposures are very much corrugated, and in those at the upper end the dip is S. 1° E. $<43^{\circ}$. These beds are black and dark grey shales, interstratified with hard grey calcareous sandstones, and bear so strong a resemblance to those near the mouth of the river as to justify the supposition that they are a repetition of them.

It would thus appear probable that the strata in the lowest five or six miles of the river stand in the form of a number of troughs, with in general overturn dips on the south side, and a depth gradually increasing to the Mountain Portage, which presents the main synclinal axis, and shews the highest set of strata at the surface. The compact yellow-weathering black dolomites are a very marked feature of these strata, and they appear in every respect to have so exact a resemblance to dolomites brought by yourself from the Grande Coupe, six miles below Grand Etang, as to leave no doubt of the equivalence of the strata. At the Grande Coupe graptolites occur in the shales associated with the dolomites, and it is not to be doubted that they belong to the group A.

In a stretch of over five miles up the valley of the Magdalen, above the rocks described, there are no exposures on the river. It is supposed however that in this part the strata of the Mountain Portage must be repeated at the surface, and finally sink beneath it, as the first display of strata beyond appears to

belong to group B. This display occurs in Porcupine Bluff, which is a prominent object about 300 paces removed from the right bank of the river, and about 300 feet high. The escarpment which forms the north side of this bluff is a hard and fine-grained sandstone or quartzite, for the most part slightly calcareous, and varying in color from yellowish-white to dull reddish-white and light reddish-brown. It is generally studded with abundance of thin small scales of black shale, and partially spotted with iron-stains probably from the decomposition of grains of iron pyrites; some parts of it weather to a brownish hue. Small veins traverse the rock in various directions, filled with vitreous quartz, and sometimes a film of calcareous matter invests the sides of the veins. Some of the veins and cracks are filled with iron ochre. The whole thickness exposed is between sixty and seventy feet, with few observed divisions into beds. Those divisions which did occur, as well as the indications derived from differences of color and of fineness in the grain of the rock, give the dip S. 8° E. <from 12° to 15°.

North of the escarpment red shale covers the surface in abundance for 150 yards, while 200 paces to the south of it the sides and bed of a brook running with the stratification support great angular masses of conglomerate limestone. Some of these masses are equal to cubes of from ten to fifteen feet, and under a thin covering of moss and vegetable soil they are closely packed together with an occasional mass of amygdaloidal trap.

On the opposite side of the river, about a mile from Porcupine Bluff in the bearing S. 82° W., which is the exact strike, there occurs another sharp pointed ridge about 200 or 250 feet in height, on which the same description of sandstones occurs.

The next exposure met with occurs in a similarly shaped hill, which we called Thunder Bluff. It is about two miles farther up the valley than Porcupine Bluff, or about a mile and a-half across the measures from the run of the last sandstones. It stands about a-quarter of a mile from the left bank of the river, opposite to a deep bend into which it points, as if there were some relation between the base of the hill

and the sweep of the stream. The hill quickly rises 300 feet over the river, but gains additional height in the run of the ridge to the westward. The rock of which it is composed is as far as observed, a light grey white-weathering arenaceous limestone, in beds varying in thickness from a-quarter of an inch to ten inches, interstratified with two beds of conglomerate limestone of one foot each and about three feet apart. The grit of the arenaceous limestone consists of grains of dark translucent quartz as large as pins' heads, very regularly disseminated through it. Some of the beds are very finely laminated, and divisional planes are sometimes marked by a film of yellowish-black matter, probably argillaceous, of an unctuous character. The conglomerate consists of flattened pebbles of compact grey or black limestone, most of which appear to be coated with the same unctuous black argillaceous matter as before, in rather thicker films. The matrix is a calcareous sandstone of a yellowish or reddish-white, approaching in appearance to some of the sandstones of Porcupine Bluff. The breadth of rock exposed is sixty paces, and the dip S. 16° E. <from 80° to 90°, giving a total thickness of about 150 feet. Some fragments of encrinal columns were observed on the rock but too obscure to be identified. This rock is probably a modified or proximate repetition of that of Porcupine Bluff, on the south side of a trough with a precipitous dip, and both of them belong to group B.

Between Thunder Bluff and the Terrace Mountains, a distance of about two miles and a-quarter, no rock in place was observed, and in the Terrace Mountains we come to the Gaspé limestones. But before proceeding farther in the direct line of section, it may be as well to describe some of the rocks exposed on the higher parts of the Magdalen, which for a considerable part of its course displays strata belonging to group B, with the strike of which it there appears nearly to coincide.

That part of the river which runs between Cold Water Brook and the head of Terrace Mountain Rapids shews nothing but Gaspé limestones, in the strike of which it runs; but about a mile and a-half northward of these rocks in the

lower part of the Flat Rapids, large masses of grey arenaceous limestone and limestone conglomerate are met with in abundance. They strongly resemble the rocks of Thunder Bluff, and being precisely in the westward strike of the Thunder Bluff beds, there cannot be much doubt that they mark the position of its continuation. In less than a mile across the measures above this there are two exposures of rock, both consisting of blackish-blue unctuous shale, interstratified with light grey calcareous sandstones of one or two inches thick, in which are abundantly disseminated dark translucent grains of quartz. These exposures are but half-a-mile from one another, the lower one though somewhat irregular dips northward <from 50° to 90°, and the upper S. 1° E. <from 80° to 90°. The beds of these exposures may be equivalent to one another on the opposite sides of a trough overlying the conglomerate limestones, which should therefore re-emerge from beneath the unctuous shales to the north. If the strata of Porcupine Bluff were continued westward in the strike they present, they would intersect the Flat Rapids in the position where the conglomerates might be expected, but unfortunately no exposures occur to enable us to confirm the supposition.

Above the last exposure there are none for upwards of three miles northward to the Great Elbow, and for about an equal distance south-westward above that bend to the Red Rapids. The Red Rapids afford the following beds in ascending order:

	Ft.	in.
Measures concealed, but supposed to be red and green shale,.........	12	0
Red shale,..	39	0
Red and green shale, the red predominating towards the base, but the green towards the top. There is a cleavage independent of the bedding, the strike of the cleavage being N. 69° E. and S. 69° W.,	25	0
Red and green shale,...	4	0
Grey calcareous shale finely laminated; some of the divisional planes have a fine unctuous coating of mottled blackish-grey and greenish-grey, and the shales are interstratified with reddish-grey strongly calcareous sandstones of one or two inches thick, subdivided into laminæ separated by glossy blackish unctuous pellicles of clay. These calcareous sandstones weather reddish-brown, and all the beds are traversed by numerous small veins of calc-spar,	8	0
Grey calcareous shale as before interstratified with slight reddish-grey calcareous sandstones and arenaceous limestones of from three to four inches thick, divided by unctuous pellicles,................	5	0

	Ft.	in.
Light reddish-grey arenaceous limestone, weathering reddish-brown, subdivided as before by thin pellicles of glossy black unctuous clay,	1	8
	94	8

The exposure is on the left bank of the river, and shews the lower part of the beds dipping S. 25° E. <36°; and as the strata accumulate on one another ascending the stream, the strike gradually bends round the western end of a trough about 100 yards up, until the upper layers dip N. 25° W. <36. The stratigraphical place of the beds is supposed to be beneath the conglomerate limestones as indicated by the occurrence of the red shale on the north side of Porcupine Bluff.

An exposure which occurs a mile and a-half above this is either in immediate relation to it or may possibly be some modification of it. The dip at the place is S. 31° E. <from 73° to 90°, and the beds in ascending order are as follows:—

	Ft.	in.
Red shales interstratified with beds of greenish hard compact calcareous sandstone of from one to two inches thick, constituting half the amount,	63	0
Measures concealed,	112	0
Red shales interstratified with greenish hard compact calcareous sandstones of one or two inches, constituting one-third of the mass,	22	0
Greenish hard and compact calcareous sandstones, interstratified with sandstones of the same color and hardness but without lime; the beds being from one to two inches thick,	34	0
	231	0

Two miles farther up, and about two and a-half miles below Cold Water Brook there is an exposure in which greenish hard compact calcareous sandstones similar to those mentioned above, but weathering somewhat brown, are inclosed in greenish instead of red shale. The beds are vertical, but the strike, which is N. 59° E., would bring them very near to the red shales farther down. Similar rocks however, about a mile farther up shew a change in the strike, which becomes N. 61° W., the dip being N. 29° E. <66°. The course of the valley changes with the strike, and the return of the valley to the previous bearing a little below Cold Water Brook, may probably be

taken to indicate a restoration of the previous strike. Accordingly three miles and a-half above Cold Water Brook, where the next exposure of rock occurs, we find the strike to be S. 64° W., very nearly what it was before. Here the strata are vertical, and consist of yellowish-drab calcareo-argillaceous shale, unctuous to the touch, interstratified with yellowish-grey shaly limestones of from one to two inches thick. Small nodules of a similar limestone are thinly disseminated in the shale. About fifty yards down the stream from these beds, and on the northwest side of their strike, probably below them in stratigraphical place, there occurs a bed of conglomerate limestone. It is twenty-four feet wide, and its pebbles consist of compact limestone with a smooth conchoidal fracture, shewing various shades of grey, and in some of the pebbles two or more shades run in narrow alternating bands. The matrix is also calcareous, with only a small amount of sand; so that the whole rock would burn to very good lime.

These rocks running directly up the valley are exposed in two additional places in the distance of a mile and a-half; they are vertical in one of the localities, and in the other inclined south-easterly at an angle of 61°.

A mile and a-half further on occur grey shales interstratified with greenish hard calcareous sandstones of from one to two inches thick, similar to beds lower down, and beyond them about half-a-mile there is a recurrence of red and green shale dipping S. 56° E. $<32°$, with another exposure of conglomerate three-quarters of a mile beyond. This conglomerate is identical in appearance and character with that last mentioned, but over half a-mile forward another bed of conglomerate is met with, whose thickness does not exceed a foot and a-half. The pebbles and matrix however, are similar to those of the previous bed, of which it may be a modification. It is associated with grey calcareous sandstones of from three to twelve inches thick. They are studded with abundance of dark translucent grains of quartz of the size of pins' heads, and form bands in a blackish-grey unctuous shale, in which also are interstratified beds of grey limestone of about an inch thick, that have the peculiarity of a fibrous structure, the fibres being

at right angles to the plane of the beds, like those of satin-spar. With the exception of the fibrous limestones the strata much resemble those towards the foot of Flat Rapids.

Between the last conglomerate band and the previous one there may be an anticlinal axis; for while the attitude of the beds at the previous one is vertical, with a strike S. 31° W. and N. 31° E., the dip of the last is S. 26° E. < from 20° to 30°, and there may be a synclinal between these beds and those of the next exposure three-quarters of a mile higher, where the rocks are exactly the same as the last, but with a dip (probably overturned) S. 66° E. < from 60° to 90°.

Red and green shales again make their appearance a mile and a-half farther up, dipping S. 26° E. < 48°, and half-a-mile beyond conglomerate limestone is seen associated with black unctuous shales dipping N. 49° W. < from 50° to 90°. Not far above this exposure the course of the valley turns rather more to the westward, apparently diverging a little from the strike; but following the strike for about two miles to the south-west we again come upon an exposure of conglomerate limestone, associated with which on the north-west side, there occurs a reddish-grey quartzite, strongly resembling that of Porcupine Bluff. This exposure is about a mile across the measures to the south-east of the Magdalen at the termination of our micrometer measurements. Near the end of these measurements another band of conglomerate accompanied by dark-grey shales presents itself on the river dipping N. 41° W. < 85°, and it is repeated about half-a-mile lower down, and about 250 paces north-west of the strike of the last, with a dip S. 31° E. < 85°, shewing the existence of a synclinal axis between the two. Shales of a character similar to that of the beds associated with these conglomerates, continued to present themselves in the remaining mile and a-half to the junction of the north and south branches, but the conglomerates themselves were not observed, though it was indicated by the strike that they could not be far removed.

It is plain from these details that as stated before, the upper part of the Magdalen runs upon group B, and if the direction of the group were maintained in its south-westerly bearing it

would apparently attain a position on the south of the Shick-Shock range of mountains. In your Report and that of Mr. Murray we ascertain that the same group exists on the north side of the range, and if as has been supposed, the range is composed of group C, it would follow that it presents a synclinal form.

Returning to the direct line of section at the mouth of Cold Water Brook, the whole volume of the Gaspé limestones is presented to us in the Terrace Mountains. The dip of the strata in these mountains appears to be very regular and uniform all the way across the measures, being from S. 5° E. to S. 14° E.< from 38° to 35°. The formation occupies a breadth of twenty-four chains, and the surface where the uppermost beds crop out is 1375 feet in geographical height above the base. In going over the mountain the exposures met with were at considerable intervals. In the section obtained therefore, there are many portions concealed, but the sequence of such beds as presented themselves for examination is here given in ascending order:—

	Feet.
Measures concealed,	30
Brownish-grey shaly limestone interstratified at intervals of from six inches to two feet, with harder limestone of the same color in beds of from two to three inches, in some of which nodules and patches of brownish-grey chert occur, with thicknesses varying from a-quarter of an inch to an inch and a-half. The chief part of the mass weathers yellowish-white, but some of the beds reddish-brown. No fossils were observed,	100
Measures concealed,	125
Brownish-grey shaly limestone, interstratified with more compact beds as before; no fossils were seen,	6
Measures concealed,	375
Brownish-grey shaly limestone with harder beds as before; no fossils were seen,	20
Measures concealed,	355
Brownish-grey shaly limestone with harder beds as before; no fossils were observed,	24
Measures concealed,	597
Brownish-grey calcareous shale interstratified with brownish-grey limestone, in beds of from one to three inches, weathering brown and yellowish-brown; no fossils were observed,	15
Measures concealed,	593

	Feet.
Brownish-grey calcareous shale weathering brown in beds, of from two to three inches, interstratified with occasional harder layers of silicious limestone of the same color, and like the shale weathering brown; no fossils were observed,	45
	2255

No fossils were observed in any of the exposed beds, though they were most carefully sought for. Only one loose fragment of limestone was met with holding organic remains. It occurred at the foot of the mountain, near the base of the formation, but the remains in it resemble those which have been brought from the top of the Gaspé limestones, near Ship-head in Gaspé Bay. Among the species were *Strophomena depressa*, *Chonetes* ——— ? and *Platyostoma* ——— ?

The crest of the hill and the summit of the formation as given above coincide, and the Gaspé sandstones are supposed to come in on the line of section some short distance forward on the gradual descent which occurs in the geographical surface. The junction of the two formations however was not seen, and the first exposure indicating a change was met with in a spot, whose place on the line would be a mile and a-half from the limestones. It occurs to the west of the line on the right bank of Cold Water Brook, nearly a mile and three-quarters from its mouth. The rock is a greenish-gray sandstone having very generally disseminated through it small scales of silvery mica. The beds are from two to six inches thick, and much studded with comminuted and carbonized remains of plants, as well as with brachiopodous shells. These shells were generally filled with iron ochre, and it was difficult to procure them sufficiently well preserved to be properly identified. The number of species did not however appear to exceed two or three, and the most abundant is identical with a small *Meganteris* (*M. elongata ?*) from the sandstones of Gaspé Bay, as well as those of Brehaut Bay, on the coast between Douglastown and Percé. The dip of these fossiliferous beds was S. 14° W. <55°.

About a mile and three-quarters southward of this, similar greenish-gray sandstones, but without fossils, occur on the

lowest tributary of Cold Water Brook, but here the dip is N. 1° W. $<14^{\circ}$. Between this tributary and the next one about a mile and a-half farther south, a hill is interposed, rising to the height of about 800 feet over the main brook. On it the sandstones are very generally seen up to the summit, which occurs about a-quarter of a mile from the second tributary. At the summit the dip is N. 18° E. $<39^{\circ}$, and the descent over the escarpment down to the tributary is very abrupt. No rock in place was observed either in the escarpment or in the tributary, but numerous large flat fragments of calcareo-arenaceous shale, abundantly marked with the carbonized remains of plants, were mingled with fragments of a harder and more compact material, sufficiently calcareous to be entitled to the appellation of a very arenaceous limestone, and these were accompanied with some fragments of chert. I am in consequence inclined to give the tributary as the southward limit of the sandstones, which between the tributary and the Terrace Mountains would thus lie in the form of a trough, measuring on the line of section about four miles and a-half across. This, agreeably to the dips observed on the opposite sides of the synclinal axis, would give for the sandstones a thickness of about 6000 feet.

Crossing the measures southward towards York River, the first exposure of the limestones met with on the south side of the trough was a little over a mile and a-half forward. It occurred about half-a-mile down an escarpment descending from the summit of a gradual rise which attains a height of 700 feet, and it consisted of about thirty feet of dark brownish-grey limestone, weathering partly white and partly brown, with patches and nodules of chert. The dip was N. 9° E. $<$ from 15° to 20°. No fossils were observed in the beds.

The distance from this position to York River is rather over four miles. Until reaching the river no exposures of rock were met with. Such as were seen on the river were calcareous. At the end of the traverse the strata consisted of dark grey compact calcareous shale, showing fine lines of stratification, but breaking up into flat fragments of from one to six inches thick, which like some of the rocks of East Terrace Mountain,

weather white. The dip of the strata was S. 1° E. <43°. Here no fossils were observed, but a few were met with two miles down the stream, not much out of the strike of these beds, where a height of 400 feet above the river was capped by 100 feet of calcareous shales of a somewhat softer character, weathering brown and white. Half a day's search produced a few fragments of *Brachiopoda* and two small species of *Orthoceras*, one of which strongly resembles an unnamed species from the limestone cliffs of Ship Head or Cape Gaspé. The dip here is S. 16° E. <45°.

The dip of these calcareous rocks and that of the last exposures in the valley of Cold Water Brook being in opposite directions, it is plain that an anticlinal runs between them. It is not possible for me however to point out the precise position of its axis. Perhaps it may occur at the springs at the source of the brook, which may issue from some crack or dislocation on the crown of the arch. But taking the thickness of the limestone formation as ascertained in the Terrace Mountains, and the dips observed on the York River and the upper part of the Cold Water valley, it appears extremely probable that between the Gaspé limestones on each side of the anticlinal there would be ample room for some part of the Lower Silurian division.

The strata constituting the base of East and West Terrace Mountains visibly coincide with the general course of the Magdalen River for two miles above the mouth of Cold Water Brook, and there is no doubt from the fragments in the bed of the stream and the form of the south bank, that they do so as far as the head of Terrace Mountain Rapids. These fragments were absent from the river until they were once more met with in the east and west reach below Clear Water Brook. Here however they reposed on the rocks of group B, but the hill which rose boldly up to the height of 700 feet not far from the south side, and so strongly resembled East Terrace Mountain in form, pretty well indicated their source. In it we have no doubt a continuation of the Gaspé limestones, which have thus a nearly east and west bearing for about eleven miles. Above Clear Water Brook the hills

on the south side did not show any of the terraced character, and it is probable that the valley of that brook may limit the extension of the Cold Water Brook trough in so far as the continuous westward run of the Gaspé limestones is concerned.

On our eastward traverse the first rocks met with after leaving the valley of York River, were observed when we crossed the Dartmouth. They consisted of twelve or fourteen feet of gray calcareous shale, interstratified with hard and somewhat arenaceous beds weathering brown and holding chert in patches and nodules. The shales resembled those capping the 400 feet hill on the York River, but they contained no observed fossils. The dip of the strata was N. 15° E. <38°, and they therefore belong to the limestones of the south side of the Cold Water Brook trough, and are probably not far from their base.

The next exhibition occurred about a mile and a-half before reaching the Ponds. Here an escarpment of sixty feet, surmounting a precipitous rise of 450 feet, presents itself, composed of brownish-gray calcareous shale in beds varying in thickness from a-quarter of an inch to two inches, in which nodules and patches of chert occur. The rock crumbles in the atmosphere into small fragments weathering white and brown, and much of it becomes exteriorly a porous earthy mass from the loss of its carbonate of lime, particularly in the upper part of the exposure. No fossils were observed in the strata. Their dip was N. 64° E. <43°.

Descending more gradually from this to the Ponds, the surface in the neighborhood both around and in the bottom of the ponds, which are not deep, is strewed with huge angular blocks of limestone, a great many of them measuring as much as six feet square and two feet thick, and some of them exhibiting obscure indications of fossils.

To the eastward of the Ponds a long distance intervened without any exposures of rock *in situ*, and we were obliged to place some dependence, in judging of the distribution, on the fragments observed on the surface, in water-courses and among the roots of overturned trees. For nearly a mile from the Ponds fragments of limestone predominated over all others;

then for three miles and a-half fragments of greenish-gray sandstone with carbonized comminuted plants excluded all others until reaching the twenty-four-feet brook flowing north to the Dartmouth. Crossing this brook, the fragments of sandstone became mingled with others of limestone, and beyond it for two miles and three-quarters the fragments consisted of limestones and calcareous shale.

This brought us to a great exposure on a small tributary of Lady-steps brook, where 300 feet of limestone are seen dipping N. 35° W. $<$54°. Having as indicated by the distribution of the fragments above given, crossed the sandstone, this exposure most probably belongs to the limestones of the east end of the Cold Water Brook trough. The north-west dip appears to indicate a turn in the calcareous belt carrying it round the flank of Mount Serpentine to the southern side, there to be interrupted by the fault described in following up the section from Grand Etang.

In his traverse from the Ponds Mr. Barlow in the first mile observed fragments of limestone only, while for three-quarters of a mile beyond fragments of sandstone prevailed; but in a farther distance of four miles and a-quarter, about the middle of which he crossed the Dartmouth, the loose masses were of limestone and calcareous shale. Beyond this they again changed to sandstone, and continued so for about three miles. The ground then became rather wet and the wood tangled, and but few upturned trees occurred to expose the rocks; but in five miles he reached a crest corresponding to that of the East Terrace Mountain, beyond which limestone was common for the rest of the distance.

It appears pretty certain from what has been said that the Cold Water Brook trough is a continuation of the synclinal of Gaspé Bay, the axis of which, from a point opposite to Ship Head or Cape Gaspé, would run about northwest for six miles, then N. 60° W. for about twenty-five miles to Lady-steps Brook, and N. 80° W. for about thirty-seven miles to the valley of Clear Water Brook.

The axis of the anticlinal to the south of this has been described by yourself as striking in upon the coast of Gaspé

Bay, near Cape Haldimand, and thence running across the entrance of Gaspé Basin and passing near the English church. Thence it would run nearly parallel with the bearing already given to the synclinal axis and probably strike near the source of the Dartmouth River, passing thence to the springs at the source of Cold Water Brook, and from them westward for upwards of twelve miles.

From what has been said it will be evident from combining the facts of the present exploration with those of your Report of 1845, that the Gaspé limestone, commencing at Ship Head or Cape Gaspé, will run along the north side of the Gaspé trough as far as Clear Water Brook, and then return along the south side of it to some point on the anticlinal axis about south of the Ponds, whence it will again run westward on the York River, beyond which its course would require farther investigation.

The sandstone within the trough east of the dislocation near Mount Serpentine, would probably be separated from that westward of it; and this, with Mr. Barlow's traverse, appears to prove that it would thus be divided into two outlying areas by the valley of the Dartmouth River.

The accompanying wood-cuts represent the supposed arrangement of the strata in the Grand Etang and Magdalen sections, the horizontal and vertical scale being one mile to one inch.

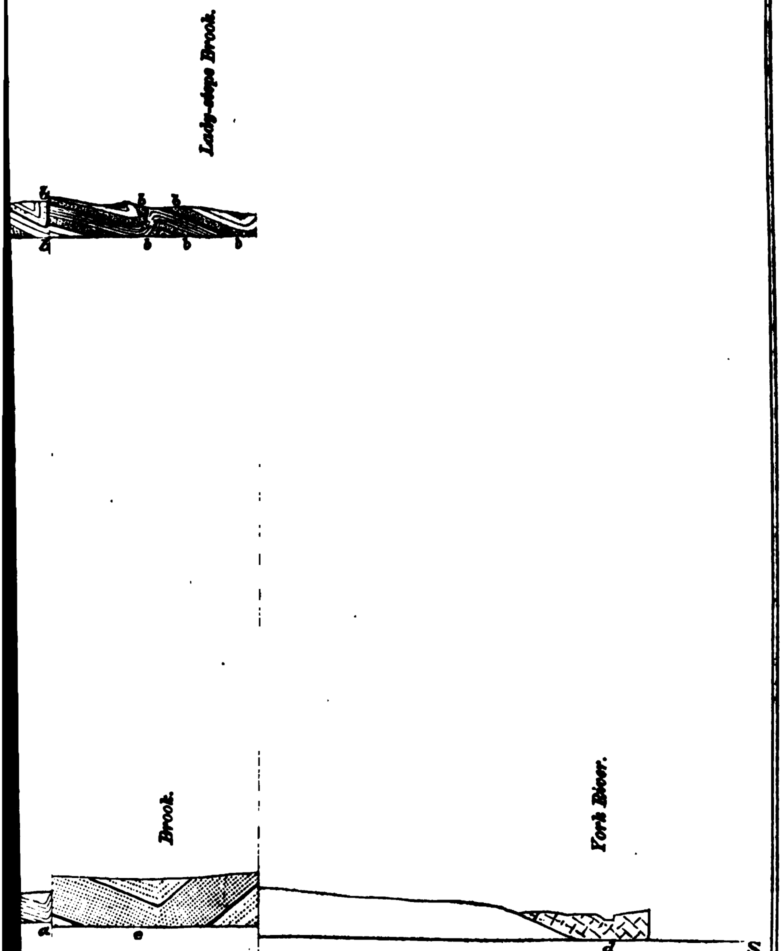
ECONOMIC MATERIALS.

The materials fit for economic application met with on the present exploration were but few. They consisted of clay fit for brick-making, serpentine, limestone, and hydraulic cement.

Common-brick Clay.—Clay fit for the manufacture of red bricks exists in abundance in the Post-tertiary deposit which has been mentioned as occupying a considerable area at the mouth of the Magdalen, as well as in several of the bays in the St. Lawrence, both above and below the Magdalen, but such clays were nowhere seen in the interior.

Serpentine.—It is probable that some of the rock of Mount

ale: One mile to one inch.



Serpentine would answer for the purposes of ornamental architecture. All of the rock however that came under my observation was too much cracked and flawed to yield any large sized blocks. It is therefore rather from the analogy which this rock bears to the serpentines of the Eastern Townships, where very beautiful blocks have been obtained, that the Gaspé locality may be expected to yield, upon farther examination, an available material.

Limestone.—The Gaspé limestones will no doubt yield abundance of material fit for burning into lime. They seem however to afford a greater number of beds capable of such an application on the coast in the vicinity of Cape Gaspé than in the area that came under my observation. This may be owing to the greater number of fossils that appear to mark the limestones of Cape Gaspé, of which those more westward seem to be almost destitute. Some of the conglomerate limestones of group B would yield good material for the purpose, as well as many of the beds interstratified in the shales of group A.

Hydraulic Cement.—The black yellow-weathering dolomites of the Mountain Portage on the Magdalen, similar to those obtained by yourself from the Grande Coupe six miles below the Grand Etang River, afford a material which gives a very strong hydraulic cement, setting in a few minutes under water to a very hard and tenaceous mass of a yellowish color. The range of the formation containing these bands being from Gaspé to Quebec and beyond, makes it probable that a considerable quantity of this stone may be obtained from various localities along the south shore of the St. Lawrence. The stone differs from that at Quebec, from which Captain now Major-General Baddeley, R.E., first prepared a cement, now manufactured by Mr. P. Gauvreau; this contains no magnesia, while the Gaspé stone is a dolomite.

Fish Offal.—Although not coming under the category of mineral substances, any one who visits any part of the Gaspé coast where a fishing establishment exists, cannot fail to notice the great quantity of offal that remains after dressing the fish, and to understand the advantage to which it might be turned as a manure.

The only fishing establishment that came under my observation was that of Messrs. F. & M. Lesperance at Grand Etang. These gentlemen employ about twenty-two boats and sixty men during the fishing season, and obtain annually 3,300 quintals of dried codfish, which is all sent to Europe. Salmon, mackerel and herring, in addition to codfish, form important items in their trade, and cod-liver oil is manufactured by them to a considerable extent.

In connection with the fishing, about 100 acres of land are under cultivation, being worked by the men when not engaged in fishing. The greatest cleanliness prevails throughout the establishment, and all the refuse around the fishing stages is each day carted away to the fields as manure. The ammonia and phosphate of lime which it contains render it a powerful fertiliser.

Although the country along the south shore looks somewhat mountainous, and the breadth of. flat land capable of cultivation appears to be but small, there are not wanting instances of considerable success in the combined operations of farming and fishing. As one instance, I may mention Mr. Isaac Green who settled in May 1856 at the mouth of the River Martin, some distance below Cape St. Ann. In that year he made from 400 trees 300 lbs. of maple sugar, and cleared land for the following quantities of grain sown :—

3½ bushels barley sown June 16, returned 70 bushels, cut Sept. 8.
16 " potatoes planted, returned 300 bushels.
1 gallon onions sown, returned 1 barrel.

In addition to this his two sons, lads of fourteen and sixteen years of age, caught codfish between July and the autumn to the value of £45. In the year 1857 he sowed and planted—

8½	bushels	barley,	returning	150	bushels.
1	"	oats,	"	20	"
1	"	wheat,	"	20	"
1	"	pease,	"	15	"
20½	"	potatoes,	"	300	"
2	gallons	onions,	"	6	"

His sons, from the 15th June to the 1st August, caught and cured 45 cwt. of codfish, and other fish to the value of £15.

We arrived at the mouth of the Saguenay on the 23rd of September, and sailed up the river to the village of Chicoutimi, which we reached on the 28th, having been somewhat delayed by head winds; here we had some difficulty in obtaining canoes. Of the two we had taken with us to Gaspé one had been abandoned on the south side of the St. Lawrence, being too much worn to be of any farther use, and the other we lost in ascending the river, having been obliged to cut it adrift in a gale of wind.

To Mr. W. E. Price of Chicoutimi I was indebted for the use of one for which he would accept no recompense, and I was farther obliged to him for much information, and for the interest he evinced in the objects of our exploration. I was likewise indebted to Mr. G. Duberger, Crown Land Agent, for his kindly supplying Mr. Scott Barlow with materials for the construction of a map of the country around Lake St. John, and to his son Mr. E. Duberger, P. L. S., for much useful information; as well as to the Rev. J. B. Gagnon, who pointed out to us the routes by which we could travel most expeditiously.

Leaving Chicoutimi on the 30th September, our equipment was sent by land to the foot of Lake Kenogami, a distance of fifteen miles. Here a second canoe was hired, by which I was enabled to visit several points on the lake, while the provisions and other materials proceeded forward in a barge. Crossing by the Bon Portage from the head of Lake Kenogami to Lake Kenogamishish, we proceeded to the foot of it and then down the River Aulnais, and from its mouth down the Belle River to Lake St. John. Lake St. John was examined along the coast and around its islands, and we ascended three of its tributary rivers for different distances, the Belle River as already mentioned, the Ouiatchouan for one mile and the Peribonka for twelve miles.

We regained the mouth of the Belle River on the 20th of October, and returning to Chicoutimi, after sending the chief portion of our party by Tadonsac as already stated, Mr. Barlow and myself proceeded on foot to Bay St. Paul, and reached Quebec two days after the others.

Geographical Description of the Country.

From the mouth of the Saguenay to Cap à l'Ouest on the right bank, a distance of fifty miles, we passed up so rapidly that I had only time to remark that on each side precipitous cliffs rise to heights of from 300 to 1100 feet, showing a succession of almost bare rocks of the Laurentian age, apparently gneiss. It is only at the mouth of some of the tributary streams that a foot-hold can be obtained for agricultural purposes. Such was observed at the junction of the River Marguerite on the left bank, about thirteen miles from the St. Lawrence, at that of the Little Saguenay eighteen miles up on the right bank, and at the St. John on the same side, a little over twenty-four miles up. In all other parts where the surface was not actually denuded of vegetation, it sometimes gave support to an abundant growth of blue-berry bushes, or some few small spruce and pine trees of different kinds.

Above Cap à l'Ouest farm-houses begin to appear, at considerable intervals at first, but approaching Chicoutimi on the one hand and the head of Ha-Ha or Grand Bay on the other, they become numerous. Advancing from Cap à l'Ouest the country becomes deeply covered with Post-tertiary clays, through the horizontal surface of which the Laurentian rocks protrude like islands, with occasional cliffs of the same facing the bays and the rivers. These clays form an excellent soil, but in some parts, more particularly in the neighbourhood of Lake St. John, to which the clays extend, they are covered over with from one to three feet of sand and gravel. The area thus covered is considerable, and it is but little resorted to for farming. Over a large part of this however, the defects of the light sandy soil might be easily obviated. With a small amount of labor the clay might be brought up from beneath the sand and gravel and spread over the surface, where mixing with the lighter material it would form an easier worked soil, equally fertile with that composed entirely of clay. The beneficial effects of such a mixture are shown by natural examples in some parts of the area on gentle slopes which have been formed by denudation, where the sand gradually thinning

becomes well mingled with the clay for some breadth near the junction, or on flat surfaces where the denudation has left the sand so thinly spread over the clay as to permit the action of the plough to effect the mixture. At the same time that such a soil possesses a great and durable fertility, it requires less labor and care in its management than the stiff clay.

The clay deposit between Chicoutimi and the head of Grand Bay has in some places a thickness of 600 feet, and where this exists land-slips are of common occurrence. They give to the surface a broken and rugged aspect, yet it is not uncommon to find whole farms situated on the remains of such *éboulements*, while others standing on the still unmoved ground might from analogy be supposed to be in positions somewhat insecure. The greatest display of these land-slips is to be seen up the Ha-Ha River and the River St. Alphonse, both of which empty into Grand Bay, and on the road between Chicoutimi and the bay. But the conditions which produce these slips extend to Lake St. John, and may be expected beyond, as the clays were observed on the banks of Lake Kenogami, at Bon Portage and on Belle River, where in many places they have a thickness of a hundred feet. It is here that large areas, as already mentioned, are overlaid with sand. On Lake St. John the clays were seen to the east of the Metabetchouan, at the Hudson Bay Company's post, and to the north-west of the River Ouiatchouan, as far as Blue Point, where a very thriving settlement is established on them. To the west and north of Blue Point and around by the north margin of the lake to the outlet, the shores are low and sandy. The sand is greyish-white, and appears to be derived from the destruction of Laurentian rocks.

The greatest length of Lake St. John is about twenty-six miles, extending in a bearing N. 20° W. from about the mouth of the Metabetchouan River to that of the Peribonka, and its greatest breadth about twenty miles from the mouth of the Ouiatchouanish to the Great Discharge. The principal rivers that flow into the lake are as follows. First the Belle River, which joins it on the south side about six miles above the Little Discharge. Its average breadth just above the position where

it is influenced by the waters of the lake is about one chain. Next is the River Metabetchouan, which is probably as large again as the Belle, and is about eight miles above it. A little more than the same distance farther is the Ouiatchouan, equal in size to the last, and six miles beyond it a somewhat smaller stream, the Ouiatchouanish. About the same distance farther we come to the most eastern part of the lake, and here enters the River Chamouchouan, and a couple of miles to the north the Mistassini. These two rivers are each of them over half-a-mile wide at their mouths, and when the waters of the lake are at their highest, which is fourteen or fifteen feet over their lowest level, the two rivers join for some way inland. At low water the shore between them, as well as above and below them presents a margin of dry sand of from one to two miles wide, forming a delta through which the rivers cut various channels. This description of coast extends all the way to the mouth of the Peribonka, which is the next stream, a distance of twelve miles, where the breadth of sand is upward of two miles, gradually tapering to nothing along the north-east shore. Inside of this extensive margin of dry naked sand there is a considerable breadth of low sandy country supplying a growth of meadow hay, with strips of small trees and brush-wood, giving farther evidence of the great amount of arenaceous material that is brought down by the rivers from the Laurentian rocks of the interior, the accumulation of which has so far filled up the whole lake as to give origin to its Indian name of *Pia-koua-kamy*, said to signify the broad shallow lake.

For the first twelve miles of its upward course the Peribonka is from a-quarter to a-half mile wide, and it presents several low sandy islands, as well as low sandy banks. But at this distance from its mouth it at once contracts to a breadth of not much over one chain, and maintains it for a-mile up. Through this sluice, bounded on each side by dark violet-blue labradorite rock, the whole volume of the river rushes with immense violence, producing a rapid current for some way down in the middle of the wider water below. Above this the river again widens out and still water prevails for a farther

distance up. It then once more contracts and again rushes between its rocky margins with the same violence as before. This alternation of still and rapid water holds for some distance up the river, and the country on each side is said to correspond with the changes, giving a swampy surface opposite the still water, while a ridge of rock runs across the rapid part, very probably indicating the strike of the Laurentian rocks through the vicinity.

On these ridges large quantities of pine timber are said to exist, and they have I believe, already furnished a large proportion of its supply to the lumbering establishment of Messrs. W. Price and Son. The timber over the country described consists generally of spruce, balsam-fir, yellow and white birch and maple on the clay, with elm and ash in low places. On the higher and more sandy parts white pine prevails.

The valley of St. John Lake may very properly be considered as commencing at the mouth of Ha-Ha Bay. This constitutes the eastern extremity of the general depression or comparatively level surface of which the area occupied by the lake is probably the lowest flat; and from this point the boundaries of the depression separate from one another, that on the north side of the Saguenay running about N. 20° W. for about thirty miles, and then changing its bearing to about N. 75° W., and in that direction running for about sixty miles. The boundary on the south side of the Saguenay separates a little from the south side of Ha-Ha Bay, in its progress running nearly S. W. It then gradually turns to about west of north, and gaining the south side of Lake Kenogami, runs along its whole length as well as Lake Vert beyond. It continues nearly in the same direction, and crosses the Metabetchouan about a mile from its mouth, coming very near the lake in a bay west of it. It crosses the Ouiatchouan at the fall about a mile from the lake and then turns about N. 55° W. Running in this direction it crosses the Ouiatchouanish about six miles up, and from Blue Point it is traceable by the eye running in the same course for twenty miles more, in which it keeps to the south of the Chamouchouan. Between the north and south boundaries where they can be no farther traced by

the eye, there is a separation of about fifty miles for the breadth of the valley, the length of which up to a line running across at the upper end of the lake is about seventy-five miles, the general bearing of the valley being N. 70° W. How much farther it may extend in the same direction I am unable to say. Thirty miles added to the distance above mentioned would give an area of 5000 square miles. But as viewed from Lake St. John the northern boundary appears to terminate, and the valley may perhaps spread out to the eastward. Indeed one of the Indians who was with me asserted that it did so, stretching along in that direction to the Seven Islands on the St. Lawrence, while in the opposite one it extended to Lake Temiscamang. But it is uncertain what dependence can be placed on his information. I may state however, that his account is in some degree corroborated by what I was given to understand last year when at the Mingan Islands. Mr. Henderson of the Hudson Bay Company's post informed me that large loose masses of limestone, which from his description I inferred were Silurian, are met with far in the interior from the Seven Islands, in a direction that appears to bend towards Lake St. John, and I am inclined to think that where these blocks were seen, some of the Silurian strata will be found *in situ*, as is the case on Lake St. John. Where flat deposits of these rocks extend the country is almost certain to be capable of cultivation.

The northern ridge is much more elevated than the southern, and it is apparently destitute of soil on the summits, which are probably not under 2000 feet above the lake. The hills on the south were not supposed to be much over 700 or 800 feet above the lake. Their tops were generally rounded, and the growth of timber upon them, which was all composed of evergreens, seemed to confirm the report of the inhabitants, that these hills were pretty well covered with soil. The range however, gains in height towards Ha-Ha Bay, and all the wood is there of a stunted growth.

The cultivateable land of the valley of St. John most probably occupies a very large proportion of its area, and as in the settled parts of it good crops seem to be the general re-

sult, it appears to me very probable that the valley will hereafter support a very considerable population. There appears to be no doubt in the minds of the settlers that they are able to grow all the kinds of grain produced in the neighbourhood of Montreal, and in equal abundance; and the unexplained superiority of climate in the valley over places more to the south renders the investigation of this part of the province a subject of considerable interest.

Mr. Blair, who superintends the works of Messrs. W. Price & Son, at Grand Bay, has kindly furnished me with the returns from the farm of the firm for the past eleven years. He informed me that the results for ten of these years had already been published in the *Toronto Globe.* I shall therefore only give the return for the season which had just past when I left Chicoutimi.

Statement of Produce raised on the Farm of Messrs. W. Price & Son, Grand Bay, under the management of Mr. Blair.

Produce.	Bushels Sown.	Yield per Bushel.	Bushels per Arpent.	Sown or Planted.	Cut.
Wheat	33	15	20	5 May to 20 May.	15 Aug. to 20 Aug.
Wheat & Rye	44	16	24	9 " to 18 "	15 " to 20 "
Barley	11	20	30	25 April to 18 "	30 July to 13 "
Oats and Rye	154	12	25	9 May to 18 "	19 Aug. to 3 Sept.
Oats	238	12	30	25 April to 8 "	20 " to 9 "
Pease	40	10	18	1 May to 8 "	31 " to 22 "
Potatoes	100	20	275–300	7 " to 27 "	6 " to 15 Oct.

Hay, total yield, 25,200 bundles; average yield per arpent, 200 bundles; cut 27th July to 19th August.

Indian Corn, a small quantity in the garden, good sized; picked green for use 15th August, and thoroughly ripe 15th September.

REMARKS.

Wheat.—A part sown on new ground was stinted by dry weather in the end of June and beginning of July.

Oats and Rye.—Being sown on new ground, they suffered from dry weather in the end of June and beginning of July.

Oats.—Being sown on new ground, they suffered from dry weather in the end of June and beginning of July.

Pease.—Other grain pressing to be cut, a scarcity of hands caused a late harvest and consequent loss by shelling.

Potatoes.—Dry and free from disease.

Hay.—Early rain and then frost in the spring destroyed the roots in some places, which produced nothing.

The cattle that are kept on the farm are a cross between the Canadian and short-horn. The principal object held in view is the raising of stock for beef and for hauling timber. In the winter straw is used liberally among the horses to induce the cattle to feed upon it more fully. Sawdust from the mill of the establishment, is used in the stable in summer to soak up the liquid manure.

DISTRIBUTION OF THE ROCK FORMATIONS.

The formations which present themselves in the area above described are in ascending order,

1. Laurentian.
2. Lower Silurian.
3. Post-tertiary or Drift.

Laurentian Series.

Between the St. Lawrence and the mouth of Ha-Ha Bay all the rocks examined consisted of gneiss. About three miles farther down the St. Lawrence than Tadousac, at a point just below Rivière à Baude, the rock is distinctly banded, and in great part composed of deep flesh-red orthoclase feldspar, which runs in layers of greater or less thickness, separated from one another by small but continuous patches of greenish hornblende, grains of quartz being sparingly disseminated. The strata dip S. 35° E. $<51°$, and they are cut by a perpendicular vein of calc-spar, which is twelve feet wide and runs N. 20° E. The calc-spar occurs in large cleavable masses and is nearly pure, there being disseminated through it only a few small crystals of copper pyrites.

On the north or left side of the Saguenay, about seven miles below the mouth of the River Marguerite, a mottled rock is met with composed of reddish-white orthoclase feldspar and small quantities of white quartz, with spots and streaks of greenish granular hornblende in some abundance, and a little brown mica. Lines indicating stratification are visible, but they are indistinct and irregular, and it was not easy to determine the general dip. At Cape Diamond, which is

the highest cliff on the same side of the river, about seven miles farther up, the gneiss consists of pale yellowish or flesh-red orthoclase striped with black hornblende in dotted lines, and mixed with a sparing amount of white quartz, the whole showing a dip about S. 20° W. $<45°$.

Not far from the extremity of the point which separates Ha-Ha Bay from the higher part of the river, the rock consists of alternations of red and grey gneiss, the former exactly resembling the beds seen near Rivière à Baude, and the latter only differing from it in color from the paler tinge of the feldspar, and the greater abundance of black hornblende. Some of the thin bands are composed almost entirely of black hornblende, with fine grains of feldspar and quartz and brown mica weathering yellowish-white; others consist largely of white translucent quartz and reddish-white orthoclase, and the whole are interstratified with occasional layers of fine grained lime-feldspar, with cleavable pyroxene. The beds are vertical and run nearly north and south. At the head of Ha-Ha Bay, at the commencement of the road to Chicoutimi, a considerable exposure occurs consisting of several varieties of rock, which run parallel with one another. At the south side of the exposure there are about 300 yards in breadth of a coarsely granular orthoclase rock, composed of pale flesh-red feldspar, with small quantities of quartz, considerable quantities of black granular hornblende and a little brown mica. The mass does not show any very distinct marks of stratification, except that it runs parallel with about twenty or thirty yards of a porphyroid feldspathic rock, the base consisting of greyish-yellow lime-feldspar with violet-colored feldspar (labradorite) imbedded in it. The individuals of the latter are large, and the rock holds crystalline masses of dark olive-green cleavable pyroxene with small portions of magnetic iron ore, and occasional patches of black mica. This mass is followed by an equal thickness of rock composed of black granular hornblende, with small quantities of striated triclinic white feldspar, the hornblende greatly predominating. Beyond this dark band succeed about 400 yards of fine grained flesh-red orthoclase rock in which are unequally mixed white translucent quartz and a sparing quantity of brown mica. In

these successive masses taken separately it is not easy to discover any arrangement of lines indicating stratification, but their parallelism to one another, and the fact that they conform to the stratification which is seen elsewhere in the vicinity, induces me to suppose that they constitute a part of it, and are not intrusive. The masses appear to be vertical, and their bearing is about S. 30° W. and N. 30° E.

About a mile east of Chicoutimi the rock which presents itself is a dull pale brownish-yellow lime-feldspar with a waxy lustre, sometimes fine grained and slightly calcareous, and sometimes made up of moderately sized cleavable masses, with occasionally a little brown mica, and in one part a small quantity of white quartz. The rock generally contains cleavable green pyroxene in considerable masses, with magnetic iron ore, and occasionally small crystals of a black mineral as yet undetermined, but supposed to be orthite. At Chicoutimi, above the mouth of the Kenogami, the rock is a reddish gneiss resembling that at the mouth of Ha-Ha Bay.

The fall which occurs at the Rocky Portage, near the foot of Kenogami Lake, descends over a porphyroid mass composed of flesh-red orthoclase feldspar, holding a small amount of white quartz with black granular hornblende and brown mica. It resembles the most southern mass at the commencement of the road from Ha-Ha Bay to Chicoutimi, with the exception of its porphyroid aspect, and it has some indistinct indications of stratification, across which there was a breadth exposed of about 400 yards.

Proceeding along Lake Kenogami, which is a narrow strip of water with a length of fifteen miles, it seems the whole way to separate the orthoclase rocks which compose the range of gneiss rising on the south, from the lime-feldspar rocks on the north. Between three and four miles up the lake, on the north side near the Au-Sable exit, the rock is a fine grained mixture of black hornblende and triclinic feldspar, exactly resembling the black band on the road from Ha-Ha Bay. Upwards of four miles farther on we have a greenish-white granular lime-feldspar, holding patches of granular pyroxene, and the rock is porphyroid from the presence of masses of a light blue feldspar. Two miles beyond this the rock is

a bluish-grey coarsely crystalline lime-feldspar, with small quantities of golden-yellow and brown mica, while about a mile from the head of the lake it consists of a pale dull yellowish-brown lime-feldspar with a waxy lustre, holding cleavable masses of dark green pyroxene, altogether resembling the rock a mile east of Chicoutimi.

On the Bon Portage, which leads from the head of Lake Kenogami to Lake Kenogamishish, a rock which is a variety of the last described, is seen in juxtaposition with one composed of orthoclase feldspar, a small quantity of quartz and brown mica, while a little farther on the road a fine grained light violet lime-feldspar occurs with patches of fine grained pyroxene.

At the Crooked Falls on the Aulnais, just below Lake Kenogamishish, the rock appears to be composed of fine grained flesh-red orthoclase and brown mica, without perceptible quartz or any indications of stratification. It is a material resorted to for mill-stones in the vicinity.

Continuing to skirt along the south range of hills bounding the valley of Lake St. John, we find as we proceed westward from Lake Kenogami, that they still give the south limit of the lime-feldspar rocks. One mile west of the Metabetchouan River the hill presents a fine grained micaceous gneiss, composed of deep flesh-red orthoclase with quartz and brown mica, the dip being southward at a high angle. Between this rock and the lime-feldspar there runs a band of sometimes fine and sometimes coarse grained flesh-red orthoclase and quartz, forming a pegmatite, of which the feldspar has the aspect of that which so often in the Laurentian series presents the arrangements peculiar to graphic granite. This is about two feet wide, and north of it the rock is of a porphyroid character, composed of greyish-white lime-feldspar, with tinges of red and green, the latter due to granular pyroxene, which forms patches with scales of mica, and it holds imbedded cleavable masses of lavender-blue feldspar (labradorite), shewing very beautiful striæ. In some narrow bands the pyroxene predominates, and is then accompanied with magnetic iron ore.

At the falls of the Ouiatchouan a similar succession occurs.

The hill is composed of micaceous gneiss, to the north of which runs a band of coarse grained pegmatite, with lime-feldspar rock beyond; but in this case the last rock consists of white lime-feldspar, brown mica, and black hornblende, the latter greatly predominating. In this direction the examination of the older rocks was not continued farther. The lake shore here began to recede from them, and there was not time for their investigation; but little doubt is entertained that the same relation between the orthoclase gneiss and the lime-feldspar rocks will follow the south range as far as the eye was able to trace it from Lake St. John.

Several exposures of rock belonging to the Laurentian series were examined between the junction of the River Aulnais and the lowest rapid of the Peribonka. They lie in a line nearly straight, the bearing of which is about N. 18° W., and they are all of lime-feldspar. The first of these exposures is at a fall on the Belle River, about four miles up from its mouth, where the rock consists of a light violet-red fine grained lime-feldspar, with patches of fine grained pyroxene, and becomes porphyroid in parts from the presence of magnificent cleavable masses of violet-blue lime-feldspar (labradorite), which are strongly striated. The breadth of this exposure is about fifty yards, and its strike appears to conform to the gneiss in the south range of hills. A mile below this the rock consists of black granular hornblende with a sparing quantity of white lime-feldspar, very similar to some bands already described, and half-way between it and the mouth there protrudes from the clay a mass of about a yard wide, composed altogether of dark-green cleavable pyroxene with curved surfaces, associated with small quantities of magnetic iron ore.

At the mouth of the river a surface of rock seen under the water of Lake St. John appeared to be dark violet lime-feldspar, identical with an exposure to be mentioned at the lowest rapid of the Peribonka. A similar rock was observed about two miles below the mouth of the Belle River, again on the outside of the island above the Little Discharge, a fourth time on the largest island between the Little and the Great Discharge, and a fifth time on the shore about two miles above

the Great Discharge, where it was accompanied with rensselaerite. All these exposures from the mouth of Belle River are so like one another that it is probable they belong to one band, which is continued to the Peribonka Rapid already mentioned. At this rapid the rock is exposed for a mile in a direction slightly oblique to the supposed strike and for 200 yards at right angles to the strike on the right or west side of the stream, while it rises in a precipice thirty feet in height on the opposite side. It presents a uniform black exterior, and in fresh fractures its color is a deep violet-blue, which characterizes large cleavable forms having strongly striated surfaces. Though no part of it that came under my observation displayed opalescence, the rock is a splendid instance of nearly pure labradorite, the only mineral disseminated through it being a pyroxene in very small quantity. On the right bank of the stream it is cut by a vertical band of a pale green mineral with a waxy lustre, unctuous to the touch, which appears to be rensselaerite. It was traced for about fifty yards, and was taken to indicate the strike of the stratification, which would very nearly correspond with the bearing of all the exposures of the rock from the mouth of Belle River.

The impression produced upon me by the geographical and geological facts ascertained is that both the north and south ranges of hills bounding the valley of St. John Lake are composed of the same orthoclase gneiss which occurs between the St. Lawrence and Ha-Ha Bay, and that the lower ground is in general underlaid by the lime-feldspars, with the exception of those parts covered by the Lower Silurian series; but to prove this satisfactorily will require a much greater amount of investigation.

On our walk from the head of Ha-Ha Bay to Bay St. Paul our opportunities of examination were not very good, as we found on entering among the hills that the ground for the chief part of the way was covered with about eight inches of snow. For the first forty-five miles of the road all the exposures of rock observed were orthoclase gneiss, resembling those on the lower part of the Saguenay. The highest and boldest hills appeared to be those about the head of Ha-Ha Lake, where

the outlines and the rocks resembled those of Cape Diamond on the Saguenay. The first indication of change was met with about six miles north of the church of St. Urbain, not very far from the road which branches off to Murray Bay. We here met with lime-feldspar rock, weathering opaque white, consisting of white lime-feldspar spotted with pale pink, and holding in sparing quantity very minute grains of pyroxene. We ascertained also that the rock which stands in the apparent south-west strike of the great mass of ilmenite you have described as existing some distance below the church, on the land of Mr. Fortin, is composed of lime-feldspar of a pale yellowish-brown passing into greenish, and that a similar lime-feldspar occurs in patches imbedded in the ilmenite. It is probable that a large part of the rocks of this vicinity may have lime-feldspar as their chief constituent, and be as you have supposed in your Report of 1856, a continuation of the lime-feldspar rock of Chateau Richer.

Before leaving the subject of the Laurentian series I may state that several bands of garnet-rock, composed almost entirely of raspberry-red garnets, with white reticulating quartz, the bands separated from one another by micaceous schists, were met with on the north-east side of Bay St. Paul, close upon the margin of the St. Lawrence. The whole occupied a breadth of about sixty feet, of which the garnet-rock constituted about one-third. The strike of the stratification was about east and west.

Lower Silurian Series.

The first and most eastern exposure of this series seen on Lake St. John, occurs on a flat island about half-a-mile to the west of the Little Discharge. The beds shew but little dip, and that not always in the same direction. They consist of yellowish-grey granular limestone, and have thicknesses of from two to eight inches. They are well stored with fossils, among which occur *Stromatocerium rugosum*, abundant and large, *Streptoplasma corniculum*, *S. profunda*, *Palaeophyllum rugosum*, *Stictopora acuta*, *Orthis testudinaria*, *O. lynx*, *O. elliptica*, *Leptaena sericea*, *Strophomena*

alternata, Rhynconella (Atrypa) increbescens, R. recurvirostr Murchisonia gracilis, M. bellicincta, Pleurotomaria umbilicata, P. supracingulata, Ormoceras tenuifilum? Orthoceras ottawaense?

The next observed locality of fossiliferous rocks on the coast is above fourteen miles south-westward from the previous one, its position being about two miles west of the mouth of the Metabetchouan River. Here the Silurian limestone was seen resting on the Laurentian rocks, both the orthoclase gneiss and the lime-feldspar running under it. The following is the ascending section of the limestone :—

	Ft.	in.
Brown compact bituminous limestone, in beds of from three to nine inches thick ; the rock presents fossils which are replaced by silica, and except when they are weathered out, but few good specimens could be procured. Among them were met with *Stromatocerium rugosum, Streptoplasma corniculum, S. profunda, Receptaculites Neptuni, Leptæna sericea, Strophomena alternata, Rhynconella recurvirostra, Murchisonia gracilis, M. ventricosa, Pleurotomaria bellicincta, Ormoceras tenuifilum? Calymene senaria,*	8	0
Blackish-brown bitumino-calcareous shale, becoming occasionally a limestone ; the only fossil observed in it was a species of *Tellinomya?*	0	
Brown bituminous somewhat granular limestone, in beds of from six inches to three feet. The fossils in it were much the same as those at the base, ...	13	
	22	

About a quarter of a mile farther west, beds of the same racter as the preceding were observed, filling up hollow the surface of the Laurentian series, and the beds slightly conforming to these hollows produced irregularities in the dip, which however upon the whole pointed towards the lake of N. E. and E.

A little over a mile farther along the shore the following section occurs in ascending order. The dip at the spot is N. 1° E. $<40°$, but it moderates in a very short distance :—

	Ft.	in.
Grey limestone in beds of from one to two inches thick interstratified with greenish-grey shale ; fossils are present in the limestone, but they are very obscure, ...	17	0
Grey limestone in beds of from one to two inches thick interstratified with greenish-grey shale, the latter less abundant than before, ...	14	0

	Ft.	in.
Yellowish-grey nodular limestone, in beds of from two to three inches thick, holding fossils, among which are *Streptoplasma profunda*, *Stictopora acuta*, *Orthis testudinaria*, *O. pectinella*, *Leptæna sericea*, *Strophomena alternata*, *Encrinurus vigilans*,	19	0
Yellowish-grey granular limestone with beds thicker and more even than the previous, with similar fossils but obscure,	10	0
Yellowish-grey granular limestone, similar to the last; the fossils are obscure; at the top fragments of encrinal columns are abundant,	22	0
	82	0

In three places, this being one, these beds are followed by black bituminous shales resembling those of the Utica slate formation, and as the fossils of the limestones beneath them are such as characterize the Trenton group down to the base of the Bird's Eye and Black River limestones, there can be no doubt that the same members of the Lower Silurian series exist on Lake St. John.

A-quarter of a mile farther on, forty-two feet of the limestone are exposed on the margin of the lake where the dip is S. 85°. E. <50°, and still farther on a thickness of seventy feet is seen. In both these instances the limestones are followed by the black shales. From the last mentioned exposure the limestones run inland, and strike round to the mouth of the Ouiatchouan, leaving the whole of Point Traverse, composed of the black shales.

On the Ouiatchouan the base of the limestone is found about three-quarters of a mile up from the mouth, resting on the Laurentian rocks, and the formation occupies the breadth of half-a-mile, leaving the remaining quarter of a mile for the black shales. Three feet at the base of the limestones are composed of yellowish-grey beds with tolerably well defined fossils replaced by silica, and weathered out on the surface; among them are *Monticulipora dendrosa (Chætetes lycoperdon)*, *Streptoplasma profunda*, *Halysites catenulatus*, (never before found so low on this continent), *Orthis lynx*, *Murchisonia gracilis*, *M. bellicincta*, *Pleurotomaria umbilicata*, *Scalites minor*. The remaining thickness up to the contact with the black shales is probably about fifty feet. The dip of the strata is from N. 25° E. to N. 70° E. <from 8° to 10°; but the descent of the

geographical surface is such that the accumulation of strata is not beyond the volume stated. The general character of these strata is that of a grey sometimes nodular limestone, in beds of from two inches to one foot in thickness, with partings of bituminous shale. The beds are moderately well supplied with fossils, among which are *Monticulipora dendrosa*, *Streptoplasma profunda*, *Leptœna sericea*, *Strophomena alternata*, *Rhynconella increbescens*, *Orthis tricenaria*, *Pleurotomaria umbilicata*, *Murchisonia bellicincta*, *Bellerophon bilobatus*, *Oncoceras constrictum*, *Isotelus gigas*, *Acidaspis Horani*. Between the limestones and the black shales on the Ouiatchouan there appears to be a fault running S. 45° E., which brings down the shales against the limestones, but the down-throw is not supposed to be a great one.

Beyond the Ouiatchouan no rocks are seen on the lake shore until we reach Flat Point, a distance of about five miles; but from this point to Blue Point, nearly six miles farther, exposures of the limestone occur very frequently the whole way, and in the latter part of the distance, from a point about half-a-mile north of the Ouiatchouanish, their contact with the black shales is occasionally well displayed. In the whole of this distance the dip is towards the lake, and the strike conforms in some degree to the turns of the coast, the general bearing being about N. But at Blue Point it turns at a right angle to the westward, and the line of contact gradually departs from the shore.

The following section of the limestones occurs at Blue Point in ascending order.

Ft.

Yellowish-grey bituminous compact limestone in beds of from two to three inches thick; the rock holds many fossils which are replaced by silica; few of them can be obtained by fracturing the rock, but they are dissolved out on the surfaces of the beds into high relief by the action of the water, and very good specimens are thus obtained. Among them are *Phytopsis cellulosum*, *Stromatocerium rugosum*, *Streptoplasma profunda*, *Receptaculites Neptuni*, *Columnaria alveolata*, and *Halysites catenulatus*; the last coral occurred loose, but having been found in place in the section on the Ouiatchouan, I do not doubt that the species belongs to the Blue Point section also. In addition to these corals there occurred *Atrypa hemiplicata*, *Rhynconella increbescens*,

	Ft.
Orthis testudinaria, O. tricenaria, Tellinomya ——? *Murchisonia gracilis, M. bellicincta, Pleurotomaria umbilicata, P. lenticularis, Subulites elongatus, Bellerophon undatus, Ormoceras tenuifilum*	42
Grey bituminous limestone in beds of from three to nine inches, with obscure fossils..	26
Yellowish-grey bituminous and somewhat granular limestone in beds of from three inches to one foot; among the fossils were *Orthis lynx, O. testudinaria, O. tricenaria, Strophomena deltoidea, S. alternata, Leptæna sericea, Atrypa hemiplicata, Murchisonia bellicincta, Pleurotomaria umbilicata, Ambonychia* ——? *Phacops callicephalus, Encrinurus vigilans, Isotelus gigas*..	32
	100

The country being flat to the westward in the strike of the limestone from Blue Point, it is probable the formation may extend much farther in that direction. I was informed of its existence about six miles up the Ouiatchouanish, but the locality was not visited.

Large loose fragments of similar limestone were met with at the head of Ha-Ha Bay, near the village of Bagotville, but none of it was seen in place there.

The distribution of the black bituminous shales has been given in describing that of the limestones beneath them. On the east side of the Ouiatchouan a visible thickness of about thirty feet skirts the coast for a-quarter of a mile with a dip N. 36° E. <from 3° to 4°. The dip at Point Traverse with the same slope becomes rather more easterly, being there N. E., and the formation is continued out to Large Island about a mile north of the point, where Mr. Barlow ascertained that the strata were flat. The greatest thickness was observed at Blue Point. The lowest beds as they strike inland here dip N. 3° W. <26°, but before reaching the extremity of the point the dip becomes twenty degrees more westward, and between the two spots an accumulation of strata equal to a hundred feet is displayed.

In every observed exposure these shales are black and strongly bituminous, and they lie in beds of from a-sixteenth to an-eighth of an inch thick. The change from the limestones below them is sudden, there being no interstratification of calcareous layers at the base. From a-quarter to half-an-inch

at the bottom was filled with fragments of encrinal columns, which being white gave to the layer a dotted grey aspect and supplied it with calcareous matter. Graptolites abound in the beds. Among them is *Graptolithus mucronatus*, and there are probably some new species. *Dictyonema* occurs, and among the fossils are *Orbicula filosa*, *O. lamellosa*, *Lingula* ——? several new species of *Orthoceras* and *Triarthus Beckii*.

On Snake Island, about a mile and a-half westward of Large Island, there occurs an argillaceous yellow-weathering limestone, of which a small exposure was seen in place. The island, which is about a mile long and a furlong wide, is covered with fragments of the same kind, and Mr. Bell and Mr. Barlow obtained from those around the island a considerable collection of good fossils, some of the forms among which appear to indicate that the island must be underlaid with rocks of the Hudson River group. Among the fossils are *Streptoplasma corniculum*, *Stictopora acuta*, *Halysites catenulatus*, *Beatricea undulata*, so common in Anticosti, *Orthis occidentalis*, *O. lynx*, as large as in Anticosti, *O. testudinaria*, *Atrypa Headi*, *Rhynconella increbescens*, *Ambonychia radiata*.

Drift.

Along the whole distance from the entrance of Ha-Ha Bay to the farthest westerly point attained on Lake St. John on the south and west shores, clays, sand and gravel are met with in many parts; but in so far as my own knowledge of them extends their distribution and thickness have already been given in the geographical description.

Marine testacea were found in clay on Belle River about half-a-mile below the lower falls, where a few individuals of *Saxicava rugosa* were brought to view by a land-slip in the bank of the river. The exact height of the position above the sea I am not able to give, but it is probably somewhere between 200 and 300 feet. Another locality presenting them was on the River Ouabouchbagama or St. Alphonse about four miles above its entrance into the upper part of Ha-Ha Bay. Here fragments of *Saxicava rugosa* were observed, and the

computed height of the spot above the sea was about 150 feet. The same species in abundance, with *Natica clausa*, *Littorina palliata*, and *Balanus crenatus*, was observed by Mr. Bell in a bed of sand of six inches thick overlaid with clay. The position is about a-quarter of a mile below the Catholic church at Chicoutimi village, and the height of it above high water-mark is only a few feet.

No ice grooves were observed on the surface of any of the exposures of rock examined, most of which were too much injured by the effects of weather to have retained them if they ever existed; many of the rocks however have that general rounded form which is supposed to result from the wearing action of ice.

ECONOMIC MATERIALS.

As on the south side of the St. Lawrence, the substances met with around Lake St. John capable of economic application were but few. They consisted of bog iron ore, mill-stones, garnet-rock, rensselaerite, labradorite, building stones, limestone, common-brick clay, and mineral waters.

Bog Iron Ore.—This ore was observed in small quantities on the east side of the Ha-Ha River, about one mile from Ha-Ha Bay on the road leading from it to Bay St. Paul. It occurred in small masses of a-quarter or half-an-inch in diameter lying somewhat detached from one another. Though they were not sufficiently numerous to be of any value, they may indicate deposits of more importance in the vicinity.

I was informed by Mr. J. Kane, Crown Land Agent at Ha-Ha Bay, that a small quantity of the ore was found in digging a ditch on a lot belonging to Mr. Joseph Tremblay in the second range of Bagot, beyond River St. Alphonse.

Mill-stones.—The feldspathic rock at the fall on the River Aulnais yields a material which has been applied to the manufacture of mill-stones. The rock is destitute of any indication of stratification, but it appears to split readily into rectangular blocks, by the application of wedges. It is made up of feldspar with mica equally distributed through it and without any

observed quartz. It must therefore be the unequal hardness of the two minerals, rather than the great resisting power of the feldspar, which renders the stone effective. I was informed by Mr. Felix Langlois that he had used the stone in his mill at the fall for grinding wheat, and that it answered the purpose remarkably well.

Garnet-rock.—In your report of progress for the year 1852, you have noticed the application of garnet rock as a polishing material when reduced to a powder, the garnet, in consequence of its hardness, which is superior to that of quartz, being sometimes used in that form as a substitute for emery. In some parts of the bands of garnet-rock met with in Bay St. Paul the garnets are so closely aggregated that much of the mass might be made available for the purpose indicated.

Rensselaerite.—The refractory nature of this mineral, which often occurs in considerable rock masses, and its applicability to various ornamental purposes, renders the occurrence of it worthy of notice. The thickness of the band observed at the rapids of the Peribonka is not sufficient to be made available; but the presence of the mineral in association with the labradorite rocks gives a reasonable expectation that it may be found in larger abundance in some parts of the district in which these rocks appear so largely to prevail.

Labradorite.—Athough none of the exquisitely beautiful opalescent varieties of the rock were observed, there is yet every probability that they will hereafter be discovered in the valley of St. John Lake; but the porphyroid and violet-blue descriptions met with would give materials capable of application to purposes of decoration. The uniform color of the mass exposed at the Peribonka rapids, and the great solid blocks that could be obtained there induced me to think that at some future time it might be turned to good account.

Building Stones.—Most of the lime-feldspar rocks met with would split into fine solid rectangular blocks for building purposes, and though of course harder than limestone, they would not be very difficult to dress. The exposure which has been mentioned near Chicoutimi would be available for building stones. It occurs behind the house of Mr. G. Duberger, where

natural rectangular blocks shew the tendency of the rock to yield useful forms of any required size from one to five feet cube. The color as has been stated is here of a yellowish-grey or brown passing into greenish.

About a mile west of the mouth of the Metabetchouan the Silurian limestone would give a good easily worked stone in blocks of almost any required size, and this will probably be resorted to for architectural purposes long before the lime-feldspars, in consequence of its greater cheapness, particularly as the same locality would afford lime for mortar.

Limestone.—Not only near the mouth of the Metabetchouan, but at almost every spot where the fossiliferous limestones were met with on Lake St. John, stone fit for burning into lime could be obtained. At the head of Ha-Ha Bay near Bagotville, the inhabitants have for several years resorted for their lime to the large loose blocks of the same fossiliferous rocks, which have been mentioned as existing there. But when these are exhausted, unless the rock should be discovered in place in the vicinity they will probably have recourse to the strata of Lake St. John.

The twelve-feet vein of calc-spar which occurs below Tadousac would afford a present supply of lime to the inhabitants of the neighbourhood, who not suspecting the properties of this rock, have hitherto been under the necessity of sending to a great distance for their supply of lime or of doing without it altogether. The latter alternative appears to have been the one generally adopted, as the buildings shewed no signs of the use of mortar in their construction. I took the opportunity of informing several of the inhabitants of the position and the economic value of the calc-spar, and although all of those to whom I gave the information appeared to be aware of the existence of the vein, none of them seemed to have entertained any idea that it would yield them a material of which they stood so much in need. Some of them [illegible]e no doubt will speedily make the information available.

Common-brick Clay.—It will be unnecessary to point out any particular spot as containing clays fit for brick-making, as the whole district from Ha-Ha Bay to the most westerly

point of Lake St. John on the east and south sides abounds with it, and scarcely any place, excluding the sandy deltas of the large rivers, could be named, within a short distance of which the clay could not be rendered available for all the bricks that will ever be required.

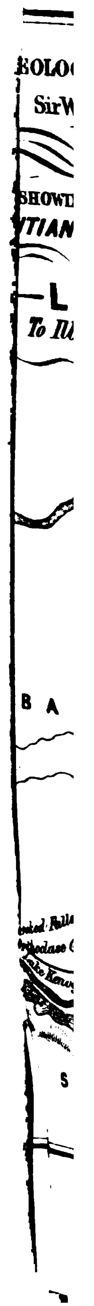
Mineral Springs.—I am not able from personal observation to point out the exact locality of any mineral spring, but I was informed that there is one not far from Chicoutimi, and another near the head of Ha-Ha Bay. If these springs, when they are examined, should prove to be possessed of any medicinal virtues, they would be of some importance to positions which are annually becoming more and more resorted to by the tourist for his pleasure and the invalid for his health.

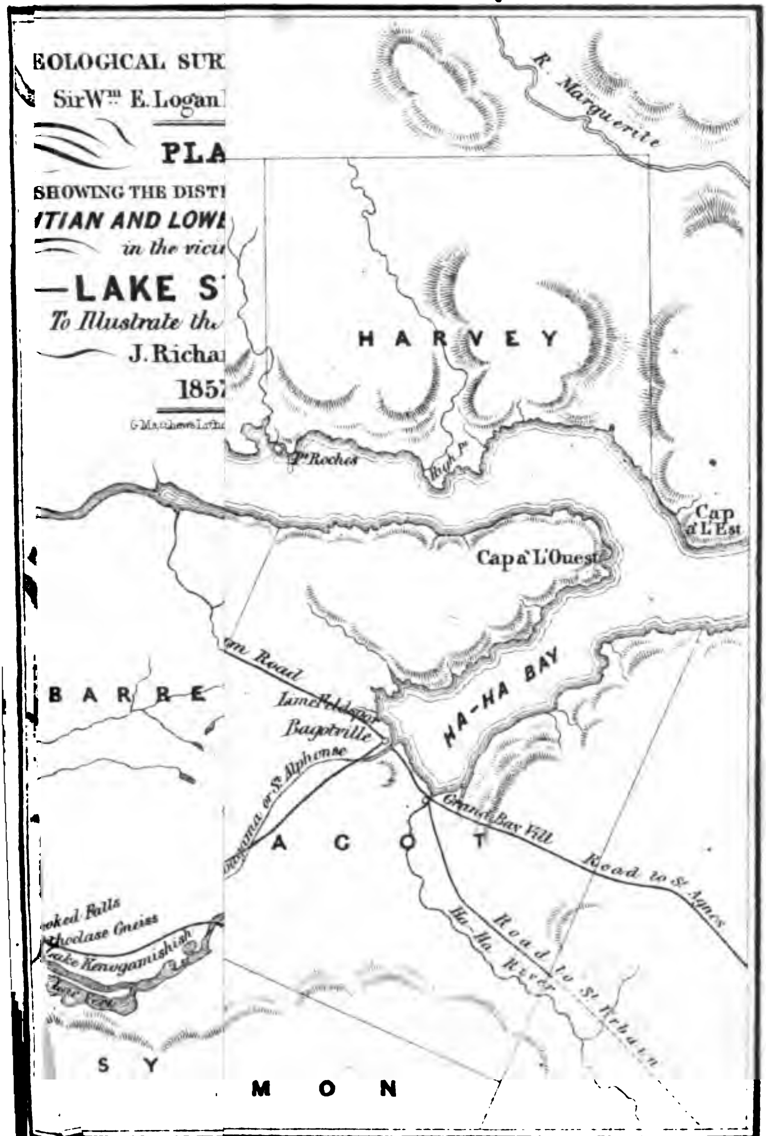
I have the honor to be,

Sir,

Your most obedient servant,

J. RICHARDSON.

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REPORT

FOR THE YEAR 1857,

OF

ROBERT BELL,

ASSISTANT ATTACHED TO THE EXPLORING PARTY OF MR. RICHARDSON,

ADDRESSED TO

SIR W. E. LOGAN, F.R.S.,

DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

MONTREAL, 1st *March*, 1858.

SIR,

During last summer and autumn, while accompanying the exploring party under Mr. J. Richardson, with which you were pleased to send me, I collected agreeably to your instructions, specimens of all the recent shells I could obtain. Not having had an opportunity to make the necessary preparations for collecting specimens in other branches of natural history, [illegible]ned almost exclusively to the mollusca as being the most easily preserved.

On the 3rd of June we embarked on board of a schooner at Quebec, intending to proceed without delay to the Magdalen River; but those in charge of the schooner finding it necessary to stop and take in ballast at Bay St. Paul on the north-east bank of the St. Lawrence, between fifty and sixty miles below Quebec, an opportunity was afforded me of collecting what shells were to be found there.

On the shoals at the mouth of the River Gouffre there occurred a number of *Sanguinolaria fusca* (Conrad). Most of the shells are thinner and less eroded, but many of them larger than any of this species afterwards found lower down the St. Lawrence. The bay is a pretty deep indentation on the left bank of the St. Lawrence, and it is well sheltered by Isle aux Coudres which lies in front of it, as well as by the high land in the interior. The shells were obtained with the animal in them in shallow ponds when the tide was out, at the end of long tracks they had made on the bottom, consisting of a soft arenaceous mud in which I sank over the ankle in walking through it. The shells varied in size from 5½ lines in length, 1¾ lines in width, and 4¼ lines deep, to 1 inch 2½ lines long, 3½ lines wide, and 11⅛ lines deep. One individual larger than others was obtained empty, but the valves united by the ligament; it measures 1 inch 6½ lines in length by 4 lines in width, and 1 inch 2⅛ lines in depth; the posterior side of it appears to be more produced than usual. The water of Bay St. Paul, although much too salt to be potable, must be largely diluted with the fresh water coming down the St. Lawrence, and down the Gouffre. On the bank of the Gouffre one specimen of *Unio complanatus* was procured, which although wanting the animal had the valves still firmly united by the ligament.

After leaving this place we were detained some days by head winds at the Brandy Pots, an island so called I was informed from the occurrence on its surface of many small pools of the color of brandy. The island is situated near the lower extremity of Hare Island, on the south side. It is about forty acres in extent, and is well clothed with grass and a few stunted trees. Hare Island is well wooded with spruce, balsam-fir and white birch, and much ground hemlock grows among the trees. Several opportunities were offered me of going ashore to collect shells. The banded and yellow varieties of *Helix hortensis* (Lam.) were found in great abundance, both on the Brandy Pots and on Hare Island. In one instance eighteen individuals, partly of the yellow and partly of the banded variety, were met with adhering to a single isolated tuft of tall grass.

causing the leaves to hang down as if laden with fruit. On Hare Island a number of dead specimens of *Succinea obliqua* (Say) were obtained.

The salt-water shells found alive consist of *Mytilus edulis* (Linn.), occurring rather abundantly on the Brandy Pots; *Sanguinolaria fusca* (Conrad) thrown up on some parts of the shore in heaps composed partly of living and partly of dead shells; *Mya arenaria*, of which only a few specimens were observed; *Littorina tenebrosa* (Gould), *L. palliata* (Gould), *L. rudis* (Mont.), were very abundant on the banks of both islands. Besides these a number of dead shells were obtained consisting of *Buccinum undatum* (Linn.), *Lottia testudinalis* (Muller sp.), and one each of *Fusus tornatus* (Gould), *Astarte sulcata* (Fleming), with a specimen of *Pectinaria Belgica*. *Buccinum undatum* and *Mya arenaria* were met with at all heights on the Brandy Pots Island from the edge of the water to the summit, the height of which might be about sixty feet over high water-mark, many of them lying on the green moss and other plants. They had the strength, enamel and color of living shells, and had probably been carried up by crows or gulls. The remains of the animal were in some of these dead shells, and the people of the island informed me that they frequently obtained the species alive between high and low water-mark.

On first landing on Hare Island we saw a number of the common Canadian hare from which it takes its name. They quickly escaped into the interior of the island on seeing us, but our Indians, returning next day, succeeded in shooting one of them. While walking through the woods of Hare Island I observed numbers of *Helix hortensis* on the trunks of trees and on the leaves of wild grasses. The species is one well known to be imported from Europe, and the number of vessels from Europe which take advantage of the safe anchorage of the place readily accounts for their presence.

Great numbers of the black guillemot, *Urea grylli* (Linn.), exist around the Brandy Pots Island. At the time of our visit they were just beginning to hatch. The crevices and holes in the cliff on the north side of the island afforded them excellent places on which to lay their eggs, and we found numbers of

their nests. There were invariably two eggs in each nest, and we occasionally caught the bird sitting on them. The birds were at the time in their jet-black summer plumage, with a white spot on the wing coverts. We consumed all we could procure, both of the birds, which were very fat, and of the eggs, and found them of excellent flavor. The head and feet of one individual and some of the eggs were preserved as specimens.

We left the Brandy Pots Island on the 12th of June, with a fair wind, which continued until we reached the Magdalen on the 14th. The Magdalen River is about 230 miles farther down than Hare Island, being about 330 miles from Quebec and sixty miles above Cape Rosier. It is one of the largest rivers on the south-east side of the St. Lawrence flowing into salt water, and affords a pretty good harbor, though not a roomy one. It is considered a good fishing-station, although it is not much used as such, except by a few Americans, who annually visit it for some months in the summer. Out in the middle of the bay, which is just below the mouth of the river, we saw codfish taken in three or four fathoms of water, as fast as they could be drawn in, and they are even caught in considerable numbers with lines and nets from the shore. One fine evening, while watching the fishermen hauling in codfish with their seines, I was astonished to observe a whole shoal of the fish, chased probably by some enemy outside, swim with such rapidity towards the shore that a large number of them grounded in the shallow water, and three or four of the foremost were thrown out about their own length on the sandy beach. Being taken by surprise, my attempts to secure some of them were not successful. They quickly struggled back into their element, and after floundering about and creating with their grounded companions a great turmoil in the shallow water, they all disappeared. When the fish approach so near the shore many of them are occasionally speared from the beach by the fishermen.

The bait used at this time for taking the cod is the capeling (*Mallotus villosus*, Cuvier). The fishermen set nets to catch the capeling in the mouth of the Magdalen, where the water

is salt, and seine nets are used for the purpose when the fish come in shoals near the shore. These shoals are occasionally so dense that, the fish on the outside preventing those on the inside from escaping, a fisherman may go in among them without a possibility of their getting away, and take them out with a bucket or any other vessel, as you have informed me your Indians did in 1845 with a frying-pan, and in this way obtain bushels of them in a very short time. On such occasions many of them are sometimes thrown on the beach by the waves, and they occasionally appeared to me to leap ashore, dying before they could struggle back. I observed hundreds of them lying dead along the margin of the water, and I can readily believe what I have heard, that in some parts they are occasionally found lying in heaps which would contain several bushels, mingled with shells, seaweed, and the remains of land plants. One heap observed by yourself in 1845 you have informed me measured thirty paces along the margin, while it was a foot deep in the middle and several feet wide, tapering away at each end.

While preparations were making to ascend the river, I had an opportunity of collecting shells in the vicinity of the harbour. Of those inhabiting salt water a few large living specimens of *Buccinum undatum* were found, among many dead ones, at Cape Magdalen, the largest of which measured 3 inches 6 lines in length. *Mytilus edulis* was observed filling up inequalities in the rock where water remained when the tide was out. At either end of the bay there was an accumulation of their dead shells at high-water mark, extending in each case about a-quarter of a mile along the shore on a rough rocky bottom, in some parts of which the shells were heaped up to a depth of two feet with a breadth of five feet. *Mesodesma arctata* (Conrad sp.) was found cast ashore alive in considerable numbers on the sandy beach on the west side of the bay. Of *Natica heros* (Say) only one living specimen was observed, but dead shells were abundant, mixed up with the accumulations of *Mytilus*. I also found in the same place a few dead specimens of a shell which I take to be *Natica triseriata* (Say). *Balanus crenatus* was found in great abundance on the rocks at

low water-mark, but never far up the shore between tides. *Lottia testudinalis* was rather scarce, but a few living specimens were met with in the same localities as *Balanus crenatus*. *Littorina tenebrosa*, *L. palliata*, and *L. rudis* were very abundant on the rocks at the extremities of the bay.

The species of land shells met with were not numerous. The most abundant was *Helix hortensis*, of which both varieties occurred, the banded variety being in the greater number. They were generally found on cedar, balsam-fir or poplar trees, and often at considerable heights from the ground, sometimes as high as fifteen feet. *H. alternata* (Say) gave me but one living specimen; its greatest diameter was $5\frac{3}{4}$ lines, but several dead shells were met with at the mouth of the river, one of them measuring $8\frac{3}{4}$ lines. I afterwards procured a living specimen of about the same measure three miles inland. *H. striatella* (Ant.) was very abundant on damp ground and among decayed leaves on the bank on the west side of the bay. *H. labyrinthica* (Say), *H. egena* (Say), and *H. lucida* (Drap.) were met with in the same locality in company with *H. striatella*. Along the same bank *H. lucida* occurred in rotten wood and among dead leaves. *H. pulchella* was another species of the same locality, as also *H. harpa*, of each of which I found only one specimen. *Succinea obliqua* (Say) was abundant on moist ground along the steep clay bank facing the east side of Cape Magdalen; and in the same locality, where the ground was more moist, *S. vermeta* (Say) occurred in great numbers. *Vetrina pellucida* (Drap.) was found among decayed leaves along the same bank on the west side of the bay, where the chief part of the *Helices* occurred.

We commenced our ascent of the Magdalen on the 20th of June, and at the end of four weeks we had reached the highest point to which canoes could be navigated. At this place the river, though shallow, was sixty feet broad, and still contained a considerable body of water. The only shell found in the river in the whole distance was *Limnea umbrosa* (Say). The shells were generally found adhering to stones in sheltered places. After passing the Mountain Portage, five miles from the mouth of the river, they were obtained in quiet pools

always occurring on the right bank of the river. The river is subject to great freshets at the melting of the snows in the spring, and we could perceive, by the injury done to the bark on the stems and branches of the trees by ice or floating wood, that these freshets sometimes raise the water ten feet above the level at which we saw it. These floods extend through the woods on each side of the summer banks of the stream and often produce changes in the channel. It is estimated by Mr. Richardson that in the sixty-two miles which we ascended there is a rise of about 2000 feet. The river, in addition to the falls, is rapid in all its parts, and the absence of shells is probably owing to these constant and periodical disquieting circumstances.

Land shells were met with in many places in the woods along the river, the species being *Helix hortensis*, *H. striatella*, *H. lucida*, *Succinea obliqua*, and *S. vermeta*. The *Helix hortensis* was a large specimen of the banded variety; it was obtained on the 29th of June about 450 feet above the sea and five miles up the river, and had a number of eggs at the aperture of the shell.

The Canada porcupine (*Hystrix dorsata*, Linn.,) was very abundant along the river; in going up we killed several. A young one which I obtained on the 9th of July was entirely jet-black, with the exception of the lower portion of a few quills on the hinder part of the back. It was heavier than a large house cat, and could run tolerably fast. The movement of the old ones does not appear to exceed in speed that of a man's ordinary walk. The old ones were generally brownish-black, with white quills tipped with black; but one was killed of a decided reddish-brown. Having run short of provisions before returning, porcupine flesh constituted our principal article of food. We always found it tender, and it appeared to me to resemble veal in taste. A day seldom passed without our procuring one of them, and one day we killed three of very large size, and saw a fourth, which escaped among the brushwood. One of these when we went to attack it appeared to wait for us, keeping its tail turned towards us, no doubt for defence, and merely turning its head to look at us. One of our Indians maintained that the animal had the power

of darting its quills, and many believe this to be the case. The quills no doubt are but slightly held in the skin of the animal, particularly in the tail, and when any object is struck by it, the barbed nature of the quill causes it to stick in the object more readily than in the skin of the animal. But of twenty that we killed not one of them darted any of its quills. We always despatched those we obtained with our hammers or with sticks, and it appeared to be rather singular that all of them but one were females. The skin of the animal is thin and tender, and I am not aware that it can be turned to any very useful purpose, but I believe that the Indians, in addition to availing themselves of the quills for embroidering birch-bark and other ornamental work, occasionally make a species of belt of the skin.

I observed a great number of flat green worms crawling about on the exterior of the intestines of one specimen while the body was being disemboweled; the worms were rather broader at one end than the other, and ribbed or striated across. They very much resembled a worm occasionally found in the animal of the *Unio*, and the largest of them was about three-quarters of an inch long. In another specimen long white worms not much thicker than threads were found folded up and tangled between the skin and the flesh. Some of these, when extended, measured about eight inches. The fat of the Canada porcupine exactly resembles bear's-grease, and we were informed that the Indians frequently sell quantities of it as such.

Besides porcupines we met with the common Canada hare (*Lepus borealis*), the red squirrel (*Sciurus Hudsonius*), the chipmonk (*Temasias lysteri*), and the flying squirrel (*Pteromys volucella*). The numerous marks of the beaver and otter indicated that these were very abundant along the river. We frequently saw trees upwards of a foot and a-half in diameter which had been cut down by the former. We also observed tracks of the bear and the caribou, and learned that two families of Indians, who had passed a winter near the high mountains at the head of the river, had killed forty of the latter during that season.

The birds we saw most frequently were the Canada grouse

(*Tetrao Canadensis*, Linn.), the king-fisher (*Alcedo alcyon*, Linn.), as well as large owls, hawks, mergansers, wild ducks, small plover, and several other birds of which I could not ascertain the species. We frequently observed in the precipitous banks of the river holes leading to the nests of the king-fisher. On the 16th of July one of the holes within about six miles of the highest part to which we took the canoes was opened. It was situated about ten feet above the level of the water, and penetrated a layer of sand in a bank of gravel. The bird flew out of the hole as we approached it, and at the depth of about four or five feet we found about six eggs lying on a nest of feathers. The number of the eggs is not quite certain, as we broke some of them in the attempt to get them out. They appeared to be quite fresh; they were pure white in color and nearly globular in form, being scarcely so large as those of the common tame pigeon.

Snakes and frogs were rather scarce, and trout were the only kind of fish we obtained in the river above the high fall of the Mountain Portage; but below this fall salmon are very plentiful in most seasons. The fishermen say that they deposit their spawn in the pool at the foot of the high fall, and that the young salmon winter there.

The wood along the Magdalen consists of white spruce, pine, cedar, balsam, white birch and poplar; and in smaller quantities, mountain ash, (which we saw in blossom on the 1st July), hard maple, yellow birch, tamarack and black ash.

When we got back to the mouth of the river the fishermen were engaged in catching mackerel, halibut, codfish and salmon. I procured a number of fresh shells of *Pecten islandicus* (Chemn.) which they had taken from the stomachs of the halibut. Some of the shells have *Spirorbis nautiloides?* adhering to them. I also obtained a number of razor shells (*Solen ensis*, Linn.), and odd valves of *Mactra ovalis*, with star-fish, most of them six-rayed, not satisfactorily identified, but resembling *Asterias rubens* and *A. neglectus*, as well as sea urchins (*Echinus granularis?*) and a number of *Scutella* resembling *S. parma*. There were great flocks of crows (*Corvus Americanus*) at the mouth of the river, but we did not see one inland.

After making the necessary arrangements, we commenced a second ascent of the river on the 2nd of August, and proceeding about twenty miles, we left our canoes, striking into the woods on foot in a course somewhat east of south. Guided by the geology of the district we subsequently turned nearly east towards Gaspé Bay, which we reached on the 16th of August, after a portion of the party had separated from us to return to the Magdalen.

On the way we killed a number of Canada grouse every day, but other game was rather scarce. The grouse were always very tame, and we generally killed them in a way that would surprise most people. When we came upon a covey we gave it a sudden start, which made the birds fly up into the surrounding trees. A rod was then cut, to the end of which was fastened a noose. This was held up close in front of the nearest bird, which generally darted its head into the noose; but if it did not do so then the noose was gently passed over the head, and by a sudden jerk the bird was brought to the ground. In this way we went from one bird to another, and usually secured all we saw that were within reach. Sometimes they are killed with stones, and it is wonderful to see how pertinaciously a bird will sit, however near the stone may whiz past it, until it receives such a blow as will knock it over. Even when struck, if not severely injured, it will occasionally remain sitting.

We killed also several porcupines, all females with the exception of one. The Indians were always very careful in preserving the under part of the tail, which they consider an excellent brush. I preserved a quantity of the quills of one individual, the largest of which measures four and a-half inches. Small snakes were very numerous in rocky places.

In the valley of Cold Water Brook through which the first part of our walk conducted us, we met with no shells. The water of the brook, which is very rapid, appeared to be low in temperature, and it was probably deficient in lime, the rocks from which it receives a large part of its supply being sandstone. On the York River I obtained a *Limnea* resembling the *L. umbrosa* of the Magdalen, but which Dr. Lea of Phila-

delphia who has most kindly examined twenty-six of the land and fresh water species obtained on our exploration, is inclined to regard as new. *Succinea vermeta* was obtained in the woods at the same place.

On the 10th of August we came to two ponds or small lakes, more than half-way between the place where we left the York River and Gaspé Basin. In the mud at the bottom of one of them *Planorbis parvus* (Say) was found, and a *Limnea* which Dr. Lea considers a new species nearest to *L. groenlandica* (Beck), but differing from it in being more attenuated; of American species it is nearest to *L. Philadelphica* (Lea). In the same place and along the margin of the pond a *Cyclas* occurred in abundance, but the shells have been too much broken to permit the species to be determined.

On the Dartmouth River a few miles above its entrance into Gaspé Bay, *Limnea catascopium*, (Say) and *Physa heterostropha* (Say) were collected. Between Gaspé Bay and Griffon Cove on the St. Lawrence, *Helix hortensis* of the banded variety was met with on the Ruisseau de la Grande Carrière about three miles from the bay. The only shell obtained in Gaspé Bay was *Mya arenaria;* but I afterwards obtained a valve of *Pecten magellanicus*, (Lam.) from a fisherman who had shortly before found it there, and judging from the large number of this species brought by yourself in 1844 from Cape Gaspé, they must be very abundant in that neighbourhood.

The woods between the Magdalen River and Gaspé Bay are of the same description, and the species of trees are about in the same proportion to one another, as on that river, with the exception of pine, of which we saw very little. Between Griffon Cove and Gaspé Bay some hard maple occurs.

After remaining a week at Gaspé Bay we ascended the Dartmouth about fourteen miles, and then crossed through the woods to the Grand Etang, which is the most extensive fishing station of those we visited on the coast. Here Mr. Richardson purchased a boat of about five tons burden in which we coasted up to the Magdalen, but as we landed but once on the way and that in the night, I had no opportunity of adding to our collection of shells.

We arrived at the mouth of the Magdalen on the 30th August, and found that the rest of the party had reached it in safety two weeks before. Putting all our provisions and luggage on board the boat, we left the river with the first fair wind, and coasted along the south-east shore about 210 miles, until reaching Apple Island, some ten or eleven miles below Cacouna; we then crossed over to the Saguenay. The various places we visited on the voyage were in the succession in which they came, Grôs Maule, Mont Louis, Peter River, Martin River, Ruisseau Vallée, River Chatte, River Capuchin, Matan, Grand Métis, Rimouski, near Trois Pistoles, Basque Island, Apple Island, Bergeronne and Tadousac.

Littorina tenebrosa, *L. palliata*, *L. rudis* and *Mytilus edulis* were found in every one of these places where rocks and pools existed between high and low water-mark. *Balanus crenatus* was observed as high as Cape St. Ann. *Purpura lapillus* (Lam.) and the young of *Buccinum undatum* from 5 lines to 1 inch 6 lines in length were found in great abundance between Ruisseau Vallée and River St. Ann. The fishermen gather them in bucket-fulls, and use them as bait after the capeling have disappeared. Of *Glycymeris seliqua* (Lam.) I found two specimens containing the animal at the mouth of Peter River, among the offal of codfish where the fishermen had just been cleaning them, and it is probable that they came from the stomach of one of the fish. On the sand-bar, at the mouth of Peter River, I met with one shell of *Unio complanatus*, one of *Pecten magellanicus*, and three of *P. islandicus*, which were of a red color. Good specimens of *Solen ensis*, the loose shells of *Mactra ovalis* and living crabs, *Plathycarcrinus irrogatus* (Say) were thrown up on the shore in considerable numbers. The largest valve of *M. ovalis* measures 5 inches 3 lines in length, and though none of the species were found containing the animal there were three which seemed rather fresh and had the valves united by the ligament.

On the shore at Rimouski I met with one specimen of *Scalaria greenlandica* (Gould), and one of *Fusus borealis* (Dekay), and being detained here some days by a head wind, I had an opportunity of collecting fresh-water shells in the neighbor-

hood. Of *Alasmadonta arctuata* (Barnes) I found a number of good specimens in the river about half-a-mile above the falls. *Physa heterostropha* was very abundant in the ditches on each side of the road between the wharf and church. *P. aurea* (Lea) was found in the Rimouski above the falls, and in a brook joining it about half-a-mile above the bridge; in this brook *Limnea apacina* (Lea) and *L. catascopium* (Say) were very abundant. In a spring above the saw-mill I found a specimen of young *L. modicella*, and in another spring near, two specimens of *Physa ancillaria* (Say).

On our visit to Basque and Apple Islands just before crossing the St. Lawrence the water was very calm, and as we sailed round parts of these islands we saw incalculable numbers of sea urchins *Echinus granularis?* adhering to the stones at the bottom where the water was not very deep. *Tellina groenlandica* was in immense numbers on the shores of both islands. After crossing the St. Lawrence, while walking on the beach below Tadousac, I observed vast numbers of *Mya arenaria*, burrowed in the sand, the largest obtained measured 2 inches 11 lines in length. *Tellina groenlandica* and the three species of *Littorina* so often mentioned before were also abundant, and the latter were observed to extend fifteen miles up the Saguenay. Below Tadousac I obtained an empty shell of *Mesodesma arctata*, and one valve of *Carduim islandicum*. A worn valve of a *Unio*, perhaps a new species, was met with on the beach, but whether derived from some of the small streams near or brought by the ice down the St. Lawrence or the Saguenay it is impossible to say.

We were informed by several fishermen that the herrings come up as far as the Brandy Pots Island, the halibut as far as Green Island, and the codfish to Grand Métis.

We reached Chicoutimi, sixty-five miles up the Saguenay, on the 27th of September, and proceeded thence to Lake St. John, thirty-five miles more, by Lakes Kenogami and Kenogamishish. At Chicoutimi one large living specimen of *Helix alternata* was obtained, and at Lake Kenogami two of *Planorbis trivolvis* (Say). The shells which were collected on Lake St. John were several varieties of *Unio complanatus*, *Margaritana*

margaritifera (Schum.), *Anodonta subcylindracea* (Lea), *Helix striatella*, *Physa elliptica* (Lea), and *Limnea modicella*.

The fish found in the lake, when we were there in October, were young salmon, pike (some of them being large), trout, white-fish and chub, and we were informed that tommycods were also seen in the lake at certain seasons. In navigating the lake we saw large flocks of black ducks, probably *Fuligula Americana*. They appeared to fly with difficulty, probably from excessive fatness.

The timber found growing round Lake St. John was of the following kinds: white birch, balsam, pine, spruce, cedar, elm, poplar, ash, yellow birch, bass-wood, and a little hard maple. Acorns were found on the shore, shewing that oak must exist somewhere in the neighborhood.

Although Lake Saint John is two degrees of latitude immediately north of Quebec, indian corn, wheat, and all other kinds of grain grow and ripen well in the settlements of the valley. Garden vegetables, including pumpkins, squashes, cucumbers and potatoes, seem to thrive as well as they do at Montreal. The land around the lake, with the exception of a sandy strip on the north side, is excellent, and is now in great part surveyed. There is a good Government road almost completed from Chicoutimi to the lake, so that great inducements are offered to settlers to emigrate thither. To find so fine a climate and such an extensive area capable of prosperous settlement so far north, and having such easy access to the sea, was to me an unexpected circumstance.

I have the honor to be,

Sir,

Your most obedient servant,

ROBERT BELL.

REPORT

OF

JAMES HALL, Esq.,

ADDRESSED TO

SIR WILLIAM E. LOGAN, F.R.S.,

DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

ALBANY, 1*st* *March*, 1858.

SIR,

In reply to your enquiry regarding the Graptolites and other allied genera, confided to me for description on behalf of the Geological Survey of Canada, partly in 1854, and partly at a subsequent time, I have the honor to inform you that six plates of the Graptolites have been engraved, and are now only waiting to be lettered, and that drawings for ten more plates are in the engraver's hands.

The description of twenty-four species accompanies the present communication, and the plates will follow as fast as they are completed.

In April 1855, I communicated to you a note upon these remarkable Graptolites, discovered in the progress of the Geological Survey during the previous year. This discovery gave for the first time a knowledge of the true forms and mode

of growth of these fossils, of which fragments and detached branches have for so many years been described as complete forms. Neither up to that time, nor so far as I am aware to the present, has any evidence of the existence of perfect forms such as these been given to the public.

Two of the species were described in the note transmitted to you in 1855, and I have preceded the description of the remainder by a repetition of that note.

I have the honor to be,

Sir,

Your most obedient servant,

JAMES HALL.

DESCRIPTIONS

OF

CANADIAN GRAPTOLITES.

NOTE upon the Genus GRAPTOLITHUS, and descriptions of some remarkable new forms from the shales of the Hudson River group, discovered in the investigations of the Geological Survey of Canada, under the direction of Sir W. E. Logan, F.R.S. By James Hall.

[Communicated in April, 1855.]

The discovery of some remarkable forms of this genus during the progress of the Canada Geological Survey, has given an opportunity of extending our knowledge of these interesting fossil remains. Hitherto our observations on the Graptolites have been directed to simple linear stipes, or to ramose forms, which except in branching, or rarely, in having foliate forms, differ little from the linear stipes. In a few species, as *G. tenuis* (Hall), and one or two other American species, there is an indication of more complicated structure; but up to the present time this has remained of doubtful significance. The question whether these animals in their living state were free or attached, is one which has been discussed without result; and it would seem to be only in very recent times that naturalists have abandoned altogether the opinion that these bodies belonged to the *Cephalopoda*.

In the year 1847 I published a short paper on the Graptolites from the rocks of the Hudson River group in New York. To the number there given, two species have since been added from the shales of the Clinton group. Other species, yet unpublished, have been obtained from the Hudson River group; and since the period of my publication in 1847, large accessions have been made to our knowledge of this family of fossils, and to the number of species then known. The most important publications upon this subject are, *Les Graptolites de Bohême*, par J. Barrande, 1850; *Synopsis of the Classification of British Rocks, and Descriptions of British Palæozoic Fossils*, by Rev. A. Sedgwick and Frederick McCoy, 1851; *Grauwacken Formation in Sachsen, etc.*, by H. B. Geinitz, 1852.

The radix-like appendages, known in some of our American as well as in some European species, have been regarded as evidence that the animal in its living state was fixed; while Mr. J. Barrande, admitting the force of these facts, asserts his belief that other species were free. It does not however appear probable that in a family of fossils so closely allied as are all the proper *Graptolitideæ*, any such great diversity in mode of growth would exist.

It will appear evident from what follows, that heretofore we have been compelled to content ourselves, for the most part, with describing fragments of a fossil body, without knowing the original form or condition of the animal when living. Under such circumstances, it is not surprising that various opinions have been entertained, depending in a great measure upon the state of preservation of the fossils examined. The diminution in the dimensions, or perhaps we should rather say in the development, of the cellules or serrations of the axis towards the base, has given rise to the opinion advanced by Barrande, that the extension of the axis by growth was in that direction, and that these smaller cells were really in a state of increase and development. In opposition to this argument, we could before have advanced the evidence furnished by *G. bicornis*, *G. ramosus*, *G. sextans*, *G. furcatus*, *G. tenuis*, and others, which show that the stipes could not have increased in that direction. It is true that none of the species figured

by Barrande indicate insuperable objections to this view; though in the figures of *G. serra* (Brong.), as given by Geinitz, the improbability of such a mode of growth is clearly shown.

It is not a little remarkable that with such additions to the number of species as have been made by Barrande, McCoy, and Geinitz, so few ramose forms have been discovered; and none, so far as the writer is aware, approaching in the perfection of this character to the American species.

Maintaining as we do the above view of the subject, which is borne out by well-preserved specimens of several species, we cannot admit the proposed separation of the Graptolites into the genera *Monograpsus*, *Diplograpsus*, and *Cladograpsus*, for the reason that one and the same species, as shown in single individuals, may be *monoprionidean* or *diprionidean*, or both; and we shall see still farther objections to this division, as we progress, in the utter impossibility of distinguishing these characteristics under certain circumstances. We do not yet perceive sufficient reason to separate the branching forms from those supposed to be not branched, for it is not always possible to decide which have or have not been ramose, among the fragments found. Moreover, there are such various modes of branching, that such forms as *G. ramosus* present but little analogy with such as *G. gracilis*.

Mr. Geinitz introduces among the *Graptolitideæ* the genus *Nereograpsus*, to include *Nereites*, *Myrianites*, *Nemertites*, and *Nemapodia*. Admitting the first three of these to be organic remains, which the writer has elsewhere expressed his reasons for doubting, they are not related in structure, substance, or mode of occurrence, to the Graptolites, at least so far as regards American species; and the *Nemapodia* is not a fossil body, nor the imprint of one, but simply the *recent track of a slug* over the surface of the slates. The genus *Rastrites* of Barrande has not yet been recognized among American *Graptolitideæ*. These forms are by Geinitz united to his genus *Cladograpsus*, the propriety of which we are unable to decide.

The genus *Gladiolites* (*Retiolites* of Barrande, 1850, *Graptophyllia* of Hall, 1849) occurs among American forms of the *Graptolitideæ* in a single species in the Clinton group of New

York. A form analogous, with the reticulated margins and straight midrib, has been obtained from the shales of the Hudson River group in Canada, suggesting an inquiry as to whether the separation of this genus on account of the reticulated structure alone, can be sustained. In the mean time we may add that the Canada collection sustains the opinion already expressed, that the *Dictyonema* will form a genus of the family *Graptolitideæ*. The same collection has brought to light other specimens of a character so unlike anything heretofore described, that another very distinct genus will thereby be added to this family. The Canadian specimens show that the Graptolites are far from always being simple or merely branching flattened stems.

The following diagnosis will express more accurately the character of the genus *Graptolithus*, as ascertained from an examination of perfect specimens in this collection.

Genus GRAPTOLITHUS, (Linn.)

Description.—Corallum or bryozoum fixed, (free?) compound or simple, the parts bi-laterally arranged, consisting of simple stipes or of few or many simple or variously bifurcating branches, radiating more or less regularly from a centre, and in the compound forms united towards their base in a continuous thin corneous membrane or disk formed by an expansion of the substance of the branches, and which in the living state may have been in some degree gelatinous. Branches with a single or double series of cellules or serratures, communicating with a common longitudinal canal, affixed by a slender radix or pedicle from the centre of the exterior side.

The fragments, either simple or variously branched, hitherto described as species of *Graptolithus*, are for the most part to be regarded as detached portions from the entire frond.

In the living state we may suppose those with the corneous disks, and numerously branched fronds to have been concavo-convex (the upper being the concave side), or to have had the power to assume this form at will. In many specimens there is no evidence of a radix or point of attach-

ment, and they have very much the appearance of bodies which may have floated free in the ocean.

Graptolithus Logani.

Plate I. Fig. 1–6. Plate II. Fig. 1–4.

Description.—Frond composed of numerous branches nearly equally disposed on two sides of a central connecting stipe, and each again subdividing nearly equally, after which they bifurcate, always near the base, with greater or less regularity; connecting membrane thin, composed of the same substance, and continuous with the branches, extending from the centre to some distance beyond the bifurcations; the branches after the third bifurcation become marked on the inner side by a row of cellules, and along the centre by an abruptly impressed line which follows the divarication of the branches; cellules minute, not prominent towards the base of the branches, being compressed vertically, and appearing like a double series with a central depressed line, becoming developed as they recede from the base. The branches beyond the disk are turned on one side and laterally flattened, and present a single series of cellules or serrations, which are moderately deep, with the serratures acute at their extremities; from twenty-four to twenty-eight in an inch. The substance of the branches upon the exterior surface near the centre, is marked by a depressed longitudinal line, which follows the ramifications, and gradually dies out as the branches become finally simple, when the surface on the same side is smooth or somewhat obliquely striated. The disk is smooth exteriorly, and from the centre is a small radicle from which the two sets of branches diverge.

This species, though in a general manner bi-lateral and presenting four principal branches, is nevertheless from the irregular division of these, usually unequal upon the two sides; and we find on examination of those figured that they are as ten and ten, nine and eleven, eight and nine, ten and eleven, seven and ten, twelve and twelve, eight and eight, eight and ten, while the half which is figured on Plate II has eleven rays.

Plate I. Fig. 1. An individual showing the exterior surface; the central portions entire, with the impression of the connecting corneous membrane, some portions of which remain still attached to the arms. The extent and outline of the membrane are very distinctly preserved. Some of the arms are broken off at the termination of this membrane or disk, while others extend to some distance beyond its limits; all however are imperfect.

The appearance of serratures is due to exfoliation, which shows the impression of the inner side upon the stone.

Fig. 2. Exterior view of another individual, in which some portions of the membrane still remain, the branches being all broken off just beyond the last bifurcation.

Fig. 3. The inner side showing the commencement of the cells, which appear in some places to be in a double series. The connecting membrane of the branches is removed in this specimen.

Fig. 4. Enlarged view of the exterior surface of the central portion of an individual.

Fig. 5. Enlarged view of the inner surface, exhibiting the appearance of a double series of cells, separated by a depressed line in the substance of the branch. In some instances these appear to be absolutely separate, while in others they are connected, showing that there is but a single series, and the apparent separation is due to the depression along the centre.

Fig. 6. An enlarged view of a fragment of a branch, showing serratures on one side, with a corresponding row of obscure, elevated ridges, which may perhaps be due to the foldings of the branch.

Plate II. Fig. 1. An individual preserving the connecting membrane almost entire, showing the sinuous outline.

Fig. 2. A specimen exhibiting the half of an individual, in which the disk is unequally extended between the rays. The margins are apparently entire between all of these, and from whatever cause or injury this inequality may be due, it existed in the animal while living.

Fig. 3. A fragment of slate preserving portions of three individuals. The connecting membrane had been removed by maceration before they were imbedded in the stony matter, but the branches are preserved to the length of more than seven inches. It does not appear that the portions preserved present the entire skeleton; on the other hand, it is almost certain from the condition of the specimens, that the branches were originally much longer. It will be observed that the branches do not all show the serrated margin at equal distances from the centre, but this is due to the accidental position assumed by the branches as they were imbedded; some present the exterior surface for a considerable distance, and gradually turning, become flattened laterally.

Fig. 4. The exterior of the base of a specimen, showing the small node or radicle which proceeds from the centre of the vinculum or connecting stipe.

The preceding illustrations are of a single species in different degrees of preservation. The manner of branching, although subject to slight modifications, is still always reliable for the purposes of distinguishing the species.

Locality and Formation.—These specimens were obtained at Point Lévy, opposite to Quebec, in a band of bituminous shale, separating beds of grey limestone. These strata belong to the Lower Silurian series, and are of that part of the Hudson River Group which is sometimes designated as Eaton's sparry limestone, being near the summit of the group; they form also the rocks of Quebec.

Collectors.—J. Richardson, Sir W. E. Logan, and James Hall.

Graptolithus abnormis.

Plate III. Fig. 1.

Description.—This species, of which only imperfect specimens have been seen, presents four principal branches diverging from the centre, two from each extremity of the vinculum, and each one of these bifurcating and branching unequally, and at unequal distances from the centre.

The forms above described do not by any means exhaust the variety presented in this collection. With a single exception however, all the specimens which offer any new light in regard to the habit of the Graptolites, indicate that the mode of growth was in the manner described, in branches radiating from a centre, or in tufts joining in a central connecting substance.

The specimens from the Canadian locality afford further evidence in confirmation of what we have elsewhere observed, that with few exceptions, the species have a limited geographical range. This locality has already, after very cursory examination, afforded eight new species of Graptolites, with one or two species which appear to be identical with those previously found in the State of New York. A comparison of specimens from more southern localities with those of New York, shows a large proportion of new species; and it now appears probable that the number of American species of *Graptolithus* previously known (about twenty,) will soon be increased by an equal number of new ones.

Locality and Formation.—Point Lévy; Hudson River Group.

Collectors.—J. Richardson, Sir W. E. Logan, and James Hall.

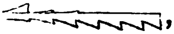
Since the date of the above communication, great numbers of Graptolites have been added to the Canada collection; and with an increased number of species, our knowledge of the structure of these animals has been very much extended. Had we at that time possessed all the materials which we now have, the subject might perhaps have been treated in a more natural order by presenting in the first place the more simple forms; but since the first two plates of the species were then engraved, I follow this note with the descriptions of others of the same character, which have been prepared since that time.

Graptolithus flexilis.

Plate III. Fig. 2-6.

Description.—Multibrachiate, bi-lateral; branches slender, flexile, bifurcating at irregular intervals; bifurcations of contiguous branches often opposite, repeated four times within one and a-half inches of the centre, having from thirty-two to forty or more branchlets at the extremities. Substance of branches thin, extremely compressed; non-celluliferous side smooth or faintly striated; celluliferous side with slight transverse indentations when compressed vertically, and with serratures when compressed laterally; serratures not deep, acute at the extremities, variable in prominence according to the position of the branch; about twenty-four in an inch. Branches often compressed in the direction of the cell to such a degree as to give an apparent double serrature, or serrature on each side of the axis. In this condition the edges of the cells are at right angles to the axis, very shallow, and not pointed.

When the celluliferous side, compressed in the direction of the cell, is uppermost on the surface of the shale, a line may be traced across the branch joining the edge of the serratures, thus showing that the two apparent serratures are but the single one, so compressed that its extremities project beyond the margin.

We have thus all gradations: the smooth surface of the branch with minute striations upon the outer side; the inner side when not compressed, with serratures showing as indented lines across the surface, ; the double serration, produced by more pressure in the same direction, ; and again, as the branch is turned around, these serratures disappearing from one side, and becoming more prominent upon the other , finally showing their full breadth as the ray is compressed in its transverse or lateral direction.

This condition, which has not been understood with regard to many species, is the principal cause of the diminution and sometimes final disappearance of cells towards the base of a branch. When both sides are serrated, a less degree of

compression, which might very naturally result towards the base, would cause the serratures to be less prominent, as is seen in many of the figures in Barrande's *Graptolites de Bohême;* in the New York Palæontology, etc. It is still true that the serratures are always less developed towards the base of the frond.

The serratures of this species differ essentially from those of any other in the Canadian collection, and from any in the New York collections or others that have come under my observation.

Fig. 2. A part of an individual showing the central connecting stipe or vinculum from the radicle, two of the main branches on one side and one on the other, with some of the branches disconnected by the breaking of the slate in which the fossil is imbedded. The celluliferous margins of the branches towards the base are imbedded in the slate, and it is only as they recede from the centre that the serratures become gradually visible, until finally some of them are exhibited of their full width as the branchlets become turned fully upon one side and laterally compressed.

Fig. 3. A fragment of slate preserving parts of three individuals, all presenting the non-celluliferous side upwards, some of the outer branchlets being turned so as to show the serratures.

Fig. 4. Enlarged view of a part of one of the branches and its branchlets, showing in some parts shallow serratures upon both sides of the branch from compression, as before explained. These sometimes appear almost equally upon the two sides, and in other parts are barely visible on one side; while one of the branchlets is so turned as to show near its extremity the full depth of the serratures.

Fig. 5. View of a portion still farther magnified, showing the branchlets where the serratures are vertically compressed.

Fig. 6. Enlarged view of a fragment which is compressed laterally.

Locality and Formation.—Point Lévy; Hudson River Group.

Collectors.—J. Richardson and E. Billings.

GRAPTOLITHUS RIGIDUS.

PLATE IV. Fig. 1–3.

Description.—Multibrachiate, bi-lateral; branches slender, cylindroid exteriorly, rigid, maintaining their width to the third bifurcation, and beyond this very gradually diminishing; bifurcations five in the space of one and a-half inches; internodes unequal, shorter near the base, and increasing towards the extremities; serratures undetermined.

In some specimens the branches are broader and flattened near the base, and the connecting bar or vinculum is broad and strong, with a small central node, the base of the radicle. Some portions of the corneous membrane or disk are preserved in a single specimen.

The subdivisions of each branch are from fifteen to twenty, or perhaps more numerous when entire; giving from sixty to eighty or more branchlets at the extremities of the frond.

A distinguishing feature of the species is its rigid and divergent bifurcation, and the almost uniform size of the branchlets.

All the specimens of this species examined are in a coarse arenaceous shale, and present the exterior or non-celluliferous side only. A single specimen has the extremities of the branches partially turned on one side, and gives some obscure indication of serratures. Individuals are extremely numerous in certain layers, and are spread out in profusion upon the surfaces of the slate, the bifurcating and interlocking branchlets presenting a net-work in which it is extremely difficult to trace the ramifications of each individual. This character is partially represented in fig. 1, pl. 4, in which the parts of the individuals, other than the principal one, are represented in a more subdued tone than they really exhibit in the specimen, where all are equally prominent.

Fig. 1. A portion of the surface of a slab of slate, in which a single individual is preserved nearly entire, with parts of several others shown in the figure.

Fig. 2. A portion of a branch of a larger individual showing the branchlets from above the second bifurcation.

Fig. 3. A fragment of slate showing the extremities of some branchlets partially turned on one side, and having obscure serrations.

Locality and Formation.—Point Lévy; Hudson River Group.

Collectors.—J. Richardson and E. Billings.

Graptolithus octobrachiatus.

Plate V. Fig. 1-6, and Plate VI. Fig. 1-3.

Description.—Frond composed of eight simple undivided branches, arranged bi-laterally, and proceeding from the two extremities of a short strong vinculum, which is subdivided, and each part again divided near the base, giving origin at each extremity to four equal rays or branchlets. Branchlets strong, linear, not sensibly diminishing in size as they recede from the centre, subangular, flattened upon the outer side, with a depressed line along the centre; obliquely striated; serratures short and strong, twenty in an inch, varying in depth according to the position of the branch; in one or two instances showing a deeper indentation.

This species presents the essential characteristic of eight simple arms or branchlets, which appear to have been subquadrangular in its living state, and when compressed laterally are scarcely broader, excepting the serratures, than when vertically compressed.

The branches are formed by the division of the vinculum at each extremity, first into two parts, making four; each of these is again subdivided almost immediately, and often so close as to present an appearance as if the four branchlets on each side originated from the same point. A careful examination however will show a little intervening space, and in one individual in its young state this feature is very characteristic.

The disk is a thick carbonaceous film, much stronger and coarser than in any of the preceding species, and corresponding in this respect to the stronger branches. It is moreover variable in form and extent in different specimens, and does not always appear to be in proportion to the size of the branches.

All the specimens yet examined present the exterior surface, so that the celluliferous face of the arms has not been seen. An impression of a short fragment of that surface of one of the branchlets shows strong, deep indentations. The vigorous aspect of this species contrasts with all others in this collection. In one specimen, where the frond is imperfect, one of the arms extends to a distance of more than eight and a half inches from the centre, while two others are more than six inches each, and these are all broken at their extremities.

In its long linear branches, this species resembles the *G. sagittarius* (Hall, Pal. N. Y., vol. I., pl. 74, fig. 1, perhaps not the European species of that name), but the branches are stronger and the serrations coarser; it is moreover associated with a group of species, all or nearly all of which are quite distinct from those of New York with which the *G. sagittarius* occurs.

Plate V. Fig. 1. A part of an individual of this species showing the exterior side with the disk partially preserved, with parts of the eight branchlets, which are seen to be gradually, turned to one side as they recede from the centre, and are compressed laterally, showing the serratures.

Fig. 2. A fragment preserving a part of the disk very per- perfect and much extended. The exterior only of the branches is shown upon the stone.

Fig. 3. Enlarged view of a portion of the exterior of a branch, showing the obliquely striated surface.

Fig. 4. A similar fragment of a branch which is turned to one side far enough to show an undulating margin caused by the serratures.

Fig. 5. A fragment exposing the serratures partially.

Fig. 6. A fragment showing the serratures as seen when the branch is compressed laterally.

Plate VI. Fig. 1. An individual retaining a part of the disk, and the outline and impression of the remainder, with the eight branches, some of which are broken off near the centre and others variously bent and folded, while two of

them retain a length of more than six inches, and one a length of eight and a-half inches.

Fig. 2. A smaller individual retaining the branches in part, and showing the lateral and exterior surfaces, with an irregular disk.

Fig. 3. A small specimen preserving the base of the branches with the disk removed. This one shows more clearly than any other specimen the bifurcation of the branches beyond the vinculum.

Locality and Formation.—Point Lévy; Hudson River Group.

Collectors.—J. Richardson, and E. Billings.

GRAPTOLITHUS OCTONARIUS.

Description.—Frond composed of four principal branches, two diverging from each extremity of the short vinculum; each branch equally subdivided near the base, giving eight branchlets which continue simple to their extremities; branchlets gradually expanding from the base; serratures slightly inclined and truncated above almost rectangularly to the direction of the outer margins and oblique to the rachis, giving a slightly obtuse extremity; about twenty-four in the space of an inch substance of the branchlets thick; divisions between the cells marked by a strongly depressed line which extends from the base of the serrature downwards as far as the second serrature below, ending near the back or lower side of the branch.

The branchlets of this species resemble those of *G. bryonoides*, and the distance of the serratures is almost the same, while in some well preserved specimens the obliquity of these parts is greater. There is also some difference in the form of the branchlets. In separate branches the characters are too nearly alike to offer the means of discrimination, unless they are in a very perfect state of preservation.

From *G. octobrachiatus* it differs conspicuously in the form of its branchlets, and in the comparative number and form of the serratures.

Locality and Formation.—Point Lévy; Hudson River Group

Collectors.—J. Richardson, E. Billings.

Graptolithus quadribrachiatus.

Plate VII. Fig. 1-5.

Description.—Frond composed of four simple undivided branches arranged bi-laterally, or two from each extremity of the vinculum; branches slender, linear, obliquely striated, usually somewhat incurved, serrated upon the inner side; serratures a little recurved, and mucronate at the tip; about twenty-four in an inch, indented to about one-third the width of the branch when completely flattened. Disk thick, strong, often extending along the branches and giving them a somewhat alate appearance; point of attachment of radicle obscure.

Almost all the specimens of this species are obscure, and all are fragmentary; in a few specimens only the serratures are exhibited with some degree of perfection. The branches are preserved in some specimens to an extent of two inches.

Figs. 1 and 2. Fragments of this species from which the disk has been entirely removed, but preserving the vinculum and bases of the branches, which show the serrations partially.

Fig. 3. An individual in which two of the branches are well preserved, showing the serratures.

Fig. 4. An enlarged view of a portion of a branch showing the form of the serratures.

Fig. 5. A fragment preserving the disk, which has the branches broken off just beyond its margin.

Locality and formation.—Point Lévy; Hudson River Group.

Collectors.—J. Richardson, E. Billings, Sir W. E. Logan, James Hall.

Graptolithus crucifer.

Description.—Frond composed of four simple strong branches united by a small thickened disk; branches broad, connected by a short vinculum; serratures nearly vertical to the direction of the branch and sloping at an almost equal angle on each side, acute at the extremity and apparently mucronate or setiferous; about twenty-four in an inch.

This species exhibits the general character of *G. quadribrachiatus*, but the branches are much stronger, and about twice the width. The serratures are scarcely oblique to the rachis, and are very clearly mucronate at the tips, while some of them present the appearance of long setæ. The imperfect preservation of the specimen examined renders it impossible to determine accurately the nature of these appendages.

In the specimen here described one of the branches is preserved to the extent of two and a-half inches, with a width of three-sixteenths of an inch to the extremity of the points of the serratures, exclusive of the setæ, the branch to the base of the teeth being five-sixths of the whole width.

Locality and Formation.—Point Lévy; Hudson River Group.

Collectors.—J. Richardson, E. Billings.

GRAPTOLITHUS BRYONOIDES.

Description.—Frond composed of four short simple branches, united at the base by a vinculum, and terminating below in a minute radicle; branches short, comparatively broad, obliquely and strongly striated from the base of the serratures to the outer edge of branch; serratures moderately oblique, the outer and inner margins making very nearly a right angle; mucronate at the tip; from twenty-four to twenty-eight in an inch.

Of several specimens in the collection none of the branches exceed an inch in length, while they are almost one-eighth of an inch in width from the tip of the solid part of the serratures to the outer edge. They are all strongly striated from the base of the serratures to the outer margin, the striæ sometimes a little curved. The serratures are usually slightly oblique, or with the longer sloping side directed towards the base of the branch, and the shorter side advanced a little beyond a right angle to the rachis. In one specimen, where the branches are less than five-eighths of an inch in length, the serratures seem to be equally or nearly equally sloping on the two sides from the tip to the base.

The vinculum is obscure; and from the mode of imbedding, in many specimens, this part might be inferred to be absent

Locality and Formation.—Point Lévy; Hudson River Group.

Collectors.—J. Richardson, E. Billings, Sir W. E. Logan, James Hall.

GRAPTOLITHUS HEADI.

Description.—Frond robust, four-branched; disk large, sub-quadrangular, moderately extended along the branches; branches strong, much elongated, sub-angular exteriorly; serratures small, acute, from twenty-two to twenty-four in an inch; fine distinctly marked striæ extend from the base of the serratures nearly across the branch.

The specimen described presents the disk, which in its diameter across the centre between the branches is nearly one inch and an eighth, or nine-sixteenths of an inch on each side of the centre; while from the centre to its extent along the branches it varies from about three-fourths of an inch in one branch to an inch in another. The substance of the disk is strong and somewhat rugose, either from its original character or from the accidents accompanying its imbedding in the rock. The specimen exhibits the inner or serrated side, and the branches are turned so as to be compressed laterally at a distance of two inches or more from the centre; one of the branches presents a length of nearly seven inches from the centre. This species is named after its discoverer, Mr. John Head.

Locality and Formation.—Point Lévy; Hudson River Group.

Collectors.—Mr. John Head, and Sir W. E. Logan.

GRAPTOLITHUS ALATUS.

Description.—Frond composed of four branches; disk much extended along the sides of the branches, giving them an extremely alate character; branches strong, angular on the lower side; upper or serrated side unknown. Some indentations on the exterior side of the branches, which may indicate the place of serratures on the opposite side are about one twenty-fourth of an inch distant.

The only specimen of this species yet recognized is a part of the disk with three of the branches, two of which pre-

sent the corneous expansion apparently entire, extending about two inches from the centre along the branches, while its margin in the indentation between the branches is not more than three-eighths of an inch from the centre. This species is much more robust than *G. quadribrachiatus* or *G. bryonoides*, and the form of the disk when preserved will always be a distinguishing feature.

Locality and Formation.—Point Lévy; Hudson River Group.

Collectors.—Mr. John Head, and Sir W. E. Logan.

GRAPTOLITHUS FRUTICOSUS.

Description.—Branches bifurcating from a long slender filiform radicle, and each division again bifurcating at a short distance above the first; branches and branchlets short, narrow linear; serratures apparently commencing in the lower axil, where there are one or two between the first and second bifurcations. Serratures somewhat obtuse at the tip; lower side longer, upper margin nearly at right angles to the rachis; about sixteen serratures in the space of an inch. Substance of the branches thin, fragile.

In one specimen the position of the serratures is such as to present elongate acute apices in one of the branches.

This species has the general habit of *G. nitidus* and *G. bryonoides*, but is very distinct in its long, slender radicle, narrow fragile branches, and distant, obtuse serrations. Two individuals only have been obtained, but the form and habit are so precisely alike, and so distinctive in both of these, as to mark it a very well characterised species.

Locality and Formation.—Island of Orleans; Hudson River Group.

Collectors.—J. Richardson, E. Billings.

GRAPTOLITHUS INDENTUS.

Description.—Frond consisting of two simple branches, diverging at the base from a slender radicle, and continuing above in a nearly parallel direction; branches narrow, slender;

serratures very oblique, somewhat obtuse, truncated above almost rectangularly to the line of the rachis; about twenty-four in the space of an inch; a depressed line reaching from the serrature to near the base or outer margin of the branch where it terminates in a small node; surface of branches striate.

This species resembles the *G. nitidus* in form, except that it is less divergent, the divergence from the base being at an angle of about thirty-six degrees for half an inch or more, after which the two branches continue nearly parallel. Though it is probable that this character may vary in some degree, it seems nevertheless to mark the species, and in numerous individuals of *G. nitidus* I have seen none with parallel or converging branches. The serratures in the two species differ in some degree in form, and the proportional distances, thirty-two and twenty-four, form a very characteristic distinction. A single fragment of a branch measures six inches, but the full extent when perfect is not known.

Locality and Formation.—Point Lévy; Hudson River Group.

Collectors.—Sir W. E. Logan, James Hall.

GRAPTOLITHUS NITIDUS.

Description.—Frond composed of two simple branches, diverging from a small radicle; branches narrower towards the base, gradually expanding towards the extremities, which in perfect specimens appear to be rounded, and the last serrations a little shortened; serratures small, shorter at the base and becoming gradually developed as they recede from this point; acute at the extremities, almost vertical to the line of the rachis, and making an angle of about sixty degrees, the two sides being almost equal in length; about thirty-two in the space of an inch. A well-defined groove or depressed line extends from the base of the serrature obliquely towards the base of the branch, and at its termination the surface of the branch is marked by a minute but distinct round tubercle.

This beautiful little species differs very distinctly from any others of this genus, in the thickened substance of its branches, the closely arranged serratures, and the minute tubercles

at the base of the grooves or striæ. The specimens usually preserve considerable substance, and are far less flattened than most of the other species, owing either to their original character or to the nature of the surrounding matrix. The impressions of the oblique lines or striæ are often well preserved in imprints of the fossil left in the slate.

The impressions of *G. bryonoides* resemble those of this species; but the branches are broader, and the striæ are less rigid and less distinctly impressed, while the absence of tubercles, and the coarser serratures, when visible, at once serve to distinguish the species.

In mode of growth and general aspect this species resembles the *G. serratulus* (Pal. N. Y., vol. 1, p. 274, pl. 74, fig. 5, a, b,) of the Hudson River shales; but in the latter the serratures are coarser and more oblique, the lower side being much the longer. The branches of that species are also more distinctly linear, while in this they become gradually wider from the base, and are very distinctly striate and tuberculate in well-preserved specimens.

The preceding description applies to the specimens of this species where the branches diverge abruptly, or nearly at a right angle, from the radicle.

Locality and Formation.—Point Lévy; Hudson River Group.

Collectors.—J. Richardson, E. Billings.

GRAPTOLITHUS BIFIDUS.

Description.—Two-branched; branches very gradually and uniformly diverging from the base to the extremities; surfaces obliquely striated; serratures moderately oblique; extremities often nearly vertical to the rachis, and submucronate (?); from thirty-eight to forty in the space of an inch; radicle short.

This species resembles in general features the *G. nitidus*, and might be mistaken for that species with the branches approximated by pressure. In several individuals examined the serratures are much closer, being from six to eight more in the space of an inch, while the general form is constant. The

outer margins of the branches are curved for a short distance from the radicle, and thence proceed in a uniform divergent line. The entire branch is very narrow at the base, but becomes gradually wider, the full width being attained at about half an inch from the bifurcation, while a few of the serratures towards the outer extremity, not having attained their full development, leave the branches narrower in that part. The same feature is observed in *G. nitidus* and others of this general character, and probably may be observed in all species where the extremities of the branches are entire.

Locality and Formation.—Point Lévy; Hudson River Group.

Collectors.—J. Richardson, E. Billings.

GRAPTOLITHUS PATULUS.

Description.—Frond composed of two simple widely diverging branches from a small radicle; branches long-linear, having a width from the base of the serratures to the back of the branch of from one-sixteenth to one-twelfth of an inch; serratures oblique, with vertical mucronate points, which from base to apex are more than half as wide as the branch. A well defined line or ridge extends downwards from the apex of the denticle two-thirds across the branch.

Fragments of this species are numerous upon some slabs of greenish or blackish-green slate where no other species occurs. The fragments are sometimes five or six inches in length, offering in different individuals little variation in width. Sometimes the branches are compressed vertically, and present the smooth linear base or exterior, which is less in width than when compressed laterally.

The lateral faces of the branches exhibit considerable variety of surface, dependant on the degree of compression, or in some instances, the replacement or filling of the interior by iron pyrites. In such cases, or when the branch is not flattened, the surface is deeply striated or wrinkled obliquely. In some of the extremely compressed individuals the surface has an appearance of vesicular structure; but this is probably due to influences attending the mineralization of the fossil, or

the filling up of the original canal, and not to the structure of the substance itself.

Locality and Formation.—Point Lévy; Hudson River Group.

Collectors.—J. Richardson, E. Billings.

GRAPTOLITHUS EXTENSUS.

Description.—Frond probably two-branched; branches long-linear, varying in width in different individuals from one-twelfth to one-tenth of an inch exclusive of the serratures, and from one-tenth to one-eighth of an inch including the serratures. Serratures oblique, with the extremities slender and nearly erect, mucronate at the tip; about twenty in the space of an inch; base of branch scarcely narrowed, showing a few smaller serratures; surface strongly striated, the striæ being preserved in those specimens which are extremely compressed.

The branches of this species bear a very close resemblance to those of *G. octobrachiatus*, but an individual in which the base is preserved shows in its peculiar curving and smaller serratures a feature which belongs only to the two-branched forms. The serratures also appear to be more slender, and are slightly closer in their arrangement; branches of the same size in the two, presenting respectively eighteen and twenty serratures.

This species in separate branches of from three to six or eight inches in length, is abundant on some slabs of decomposing grayish-brown shale, associated with *G. bryonoides*, *G. nitidus*, and others.

Locality and Formation.—Point Lévy; Hudson River Group.

Collectors.—J. Richardson, E. Billings, Sir W. E. Logan, James Hall.

GRAPTOLITHUS DENTICULATUS.

Description.—Frond apparently consisting of two broad branches, (the base and junction of which are obscure in the specimen;) margins defined by a rigid line, beyond which on the inner side, are serratures having the form and charac-

ter of small denticulations inserted upon the margin of the branch and vertical to its direction, broad at base, abruptly tapering above, and ending in mucronate points; about sixteen in the space of an inch.

This very peculiar species is readily recognised by the denticulations, which have the character of small sharp teeth fixed upon the margin of the branch. These denticles are more widely separated than those of any other species observed, as well as different in character.

Locality and Formation.—Point Lévy; Hudson River Group.

Collectors.—Sir W. E. Logan, James Hall.

GRAPTOLITHUS PRISTINIFORMIS.

Description.—Stipe simple, with serratures on both sides; serratures closely arranged, very oblique, acute, mucronate; thirty-two in the space of an inch.

This species approaches to *G. pristis* (Pal. N.Y., vol I., p. 265, pl. 72, fig. 1), but the serratures are more ascending, and the extremities more distinctly mucronate. The specimens observed however, are imperfect fragments, which are very closely compressed, being barely a film upon the surface of the shale, and the determination is somewhat unsatisfactory.

Locality and Formation.—Point Lévy; Hudson River Group.

Collector.—J. Richardson.

GRAPTOLITHUS ENSIFORMIS.

(*Genus* RETIOLITES? Barrande.)

Description.—Stipe simple, sub-ensiform or elongate-spatulate, usually broader in the middle and narrower towards the extremities; a central rib, with strongly marked obliquely ascending striæ which reach the margins; serratures obscure, apparently corresponding to the striæ; margin usually well defined.

Several specimens of this form occur on a single slab of slate, associated with *G. tentaculatus* and *G. quadribrachiatus*.

The oblique striæ apparently indicate the direction of the serratures, and in one specimen there is an appearance of obtuse indentations upon the margin; but it is scarcely possible at the present time to define satisfactorily the character of these serratures. In form and general character this species differs from all the others sufficiently to be readily distinguished.

Locality and Formation.—Point Lévy; Hudson River Group.

Collectors.—J. Richardson, Sir W. E. Logan, James Hall.

GRAPTOLITHUS TENTACULATUS.

(*Genus* RETIOLITES, Barrande.)

Description.—Stipe simple, linear, elongate-lanceolate or sometimes elongate-elliptical when entire; midrib double, extending much beyond the apex of the frond; exterior margins when entire, reticulate and armed with mucronate points, (and with mucronate points alone, or smooth, when imperfect,) with an extended setiform tentacle-like process from each side of the basal extremity; substance of the centre reticulate or cellular?

This species presents much variety of appearance dependant upon the condition of preservation. In specimens most nearly entire, the double midrib often extends beyond the apex nearly as far as the length of the frond; the margins present a series of oval or sub-hexagonal reticulations, every second one (and sometimes each one,) of which is armed by a minute mucronate spinule. When these outer cells or reticulations are broken away, the transverse walls between them often remain, and the specimens then present an undulating margin, with a short mucronate extension, which is the original wall between the marginal reticulations, and which is continuous with the striæ or fibres which traverse the frond from the midrib to the margins. On each side of the basal extremity the long setiform fibres extend obliquely forward to the distance of half an inch, and between these are two short terminal ones, like the processes on the sides of the frond.

In many specimens the whole exterior reticulate portion is removed, leaving the frond with straight or nearly straight parallel sides, the long extended midrib above, and the two setiform processes from the lower extremity; while in some specimens these parts also are removed. The serratures cannot well be determined in any of the numerous individuals examined, but they doubtless correspond to the vein-like markings of the centre, and the reticulate marginal extension.

Some specimens indicate that the central portion may be finely reticulate, which character, with that of the exterior, would be regarded as sufficient to warrant us in referring it to the genus *Retiolites*.

Locality and Formation.—Point Lévy; Hudson River Group.

Collectors.—J. Richardson, Sir W. E. Logan, James Hall.

PHYLLOGRAPTUS.

Among the various forms in this Canadian collection of *Graptolitideæ* there are several which approach in general form to *G. ovatus* of Barrande, and *G. folium* of Hisinger. They present however some differences of character, varying from broad-oval with the extremities nearly equal, to elongate oval or ovate, the apex usually the narrower, but in a few instances the base is narrower than the apex. These forms are sometimes extremely numerous in the shales, and present on a cursory examination a general similarity to the leaves of large species of *Neuropteris* in the shales of the coal measures.

Instead of the narrow filiform mid-rib represented in the figures and descriptions of the authors mentioned, these specimens present a broad linear mid-rib continued from the apex to the base, and extended beyond the base in a slender filiform radicle, usually of no great extent, but in some instances nearly half an inch in length. The mid-rib is rarely smooth, varying in width, with its margins not often strictly defined. In examining a great number of individuals of one species, I have discovered that this mid-rib is serrated; and though for the most part the serratures are obscure, they nevertheless present all the characteristics which they exhibit in grap-

tolites of other forms, in which the branches have been compressed vertically to the direction of the serratures.

In this view, the lateral leaf-like portions appear to be appendages to the central serrated portion; but these are nevertheless denticulate on their margins, and the intermediate spaces are well-defined, as if admitting of no communication by serratures or cellular openings with the centre.

In another species the central axis or mid-rib is strong and broad, often prominent and distinctly serrate, the edges of the interspaces being all broken off as if the extremities had been left in the slate cleaved from the surface. At the same time the lateral portions are so well preserved as to show distinct cellules upon each side. We have therefore three ranges of cells visible, the central axis projecting at right angles to the two lateral parts. This remarkable feature leads to the inference that this graptolite was composed of four semi-elliptical parts joined at their straight sides, and projecting rectangularly to each other, presenting on each of the four margins a series of serratures, which penetrating towards the centre, were all united in a common canal, and all sustained upon a simple radicle.

In another more elongate form, the specimens examined are extremely compressed, and I have not been able to detect serratures in the axis, which however is sufficiently wide to admit of this feature.

For these remarkable forms, whether consisting of bilateral or quadrilateral foliate expansions, or with two or four series of cellules, I propose the name of PHYLLOGRAPTUS, from their leaf-like appearance when compressed in the slaty strata.

It is easy to perceive how bodies formed as these are may present different appearances, dependant upon the line of separation of the parts by the slaty luminæ. When separated longitudinally through the centre, the cells of the parts laterally compressed would be seen with the mid-rib not strictly defined; and the bases of the cells of that part vertically compressed, scarcely or not at all visible. When a small portion of the base of that part which is vertically compressed is preserved, the bases of the cells remain and mark the axis.

When instead of being imbedded so that two parallel sides are compressed laterally and the other vertically, the whole frond lies in an oblique position, the two adjacent rectangular parts are spread open and flattened upon the surface of the slate, the specimen then appears as if the cells were conjoined at their bases, or as if separated by a filiform mid-rib. An individual compressed in this manner and then separated through the middle, will present the bases of the two adjacent divisions with the cells lying obliquely to the plane of the slaty laminæ. These and other varieties of appearance are due to the position in which the fossil was imbedded, and the direction of the cleavage or lamination of the slate.

Phyllograptus. (New Genus.)

Description.—Frond consisting of simple, foliate expansions celluliferous or serrated upon the two opposite sides; margins with a mucronate extension from each cellule; or of similar foliate forms united rectangularly by their longitudinal axes, and furnished on their outer margins with similar cellules or serratures, the whole supported on a slender radicle.

These bodies which usually appear upon the stone in the form of simple leaf-like expansions, may possibly have been attached in groups to some other support; but the form of some of them, and the character of the projecting radicle at the base, indicates that we have the entire frond. These forms furnish perhaps the best illustration of all the *Graptolitideæ*, of the lesser development of the cells at the base, and their gradual expansion above, until they reach the middle or upper part of the frond. Many of them diminish from the centre upwards, and rarely the cells are more developed above the centre, reversing the usual form, and leaving the narrower part at the base.

Phyllograptus typus.

Plate VIII. Fig. 1-11.

Description.—Frond elliptical, elongate-ovate or lanceolate,

broad-oval or obovate; margins ornamented by mucronate points; serratures closely arranged, about twenty-four, rarely twenty-two and sometimes twenty-six in an inch, usually obscure at the margins; axis or mid-rib broad, often crenulate or serrate; radicle usually short; frond robust.

This species assumes considerable variety of form; and from the examination of a few specimens of the extremes of the series one might be disposed to regard them as distinct species. After examining several hundred individuals however, I have not been able to find reliable characters in the form, or subordinate parts, to establish specific differences. The individuals figured represent the principal varieties noticed, though a greater number of forms might have been given. I have not thus far observed forms intermediate between the short broad ones and the more elongate oval ones; but it is probable that larger collections will furnish such. The number of serratures in entire fronds varies in different individuals from twenty-five or twenty-eight to fifty on each side, depending on the size and form of the specimen. The smallest examined have about twenty-five on each side.

The specimens of this species examined are all so much compressed that the rectangular arrangement of the parts of the frond, as seen in *P. ilicifolius*, cannot be shown, the only evidence of this character being the serratures along the central axis, which are transverse to those of the two sides.

Figures 1, 2, 3, 4. Examples of the ordinary forms of this species. Fig. 1 shows a smooth axis; while figures 2, 3 and 4 show indistinct serratures along the mid-rib.

Figures 5, 6, 7. Specimens which are more elliptical than the ordinary forms; the mid-rib or axis is well defined, but preserves no evidence of serratures.

Fig. 8. A broad oval form, showing serratures along the axis.

Fig. 9. An obovate form, showing serratures along the axis.

Fig. 10. A very large and elongate frond, showing more than fifty serratures on each side; the central axis shows no serratures.

Fig. 11. A fragment of slate preserving twelve individuals of small size, upon the surface.

Locality and Formation.—Point Lévy; Hudson River Group

Collector.—J. Richardson.

PHYLLOGRAPTUS ILICIFOLIUS.

Description.—Frond apparently broadly oval or ovate, with the margin ornamented by mucronate points; mid-rib or axis broad, serrated; the extension of the serratures broken off in the separated laminæ of shale; radicle short. Serratures from thirty to thirty-two in the space of an inch, varying slightly with the proportionate length of the frond.

The form in reality however is that of two broadly oval or ovate leaves or fronds, joined rectangularly at their centres or by the longitudinal axis, and in a transverse section presenting a regular cruciform figure. The expansions of the two sides, which are laterally compressed, show distinct serratures or cells with projecting mucronate extensions. Those which are vertically compressed have their outer portions broken off in the separated laminæ of slate, and present the bases of the cells, which, having sometimes been filled and distended with mineral matter before imbedding, are very conspicuous. In a few instances the cells of the lateral portions are filled in the same manner, presenting the character of curving, conical tubes, with the broader extremity outwards.

The condition of preservation in several species examined is such as to render unavoidable any other conclusion as to their mode of growth than the one I have given above, however anomalous it may seem. This species differs from *P. typus* in its thicker substance, proportionally shorter and broader form, and more closely arranged serratures.

Locality and Formation.—Point Lévy; Hudson River Group.

Collector.—J. Richardson.

PHYLLOGRAPTUS ANGUSTIFOLIUS.

Description.—Frond elongate-elliptical or elongate-lanceolate,

closely serrated; serratures furnished with mucronate extensions, about twenty-four in the space of an inch; mid-rib broad, smooth; radicle scarcely preserved.

This species is readily distinguished from either of the preceding by its narrow and elongate form. The individuals examined are very numerous, but being for the most part upon slaty laminæ, which are extremely compressed, they preserve scarcely any substance; a mere outline with a more brilliant surface being almost the only remaining character by which they are recognized.

The individuals of this species are, in several specimens, equally abundant with those of *Phyllograptus typus* represented in pl. 8, fig. 11. The mucronate extensions upon the margins of this species are not so abrupt as in *P. typus* and *P. ilicifolius*, the substance of the cell-margin being more extended along the mucronation. The number of serratures upon each side of the frond varies according to the size of the individual, being ordinarily from eleven or twelve to twenty-four, while in a single individual of nearly two inches in length there are forty-three or forty-four on each side. The mid-rib in this species though broad, like those of the preceding species, is not conspicuously serrate in any of the specimens examined. This feature how ever may have been obliterated by pressure.

Locality and Formation.—Point Lévy; Hudson River Group

Collector.—J: Richardson.

Phyllograptus similis.

Description.—Frond broad-oval; margins ornamented by slender, sub-mucronate serratures, which are closely arranged, being in the proportion of thirty-two to an inch, usually from thirteen to sixteen upon each side; axis disjoined; radicle unknown.

This species exhibits much variety of aspect. The more perfect forms are broadly oval, the diameters being about as six to seven. The central portion is open and free from any organic substance, as if there had originally been a cavity in the place of the longitudinal axis. In other specimens the

parts are separated at one extremity, and appear like three or four branches closely joined at the other extremity, giving it the aspect of a four-branched frond. On examining numerous specimens they appear to have been originally arranged like the species of this genus already described, with perhaps this difference, that the margins of the axial portion were not closely united, or were quite disjoined along the centre. From the equal extremities of the frond, and the almost rectangular serratures, conjoined with the very obscure condition of the specimens, it has not been possible to determine whether the separation of the parts at the extremities has taken place at the base or the summit.

This species occurs associated with *G. Logani* and *G. quadribrachiatus*.

Locality and Formation.—Point Lévy; Hudson River group.

Collectors.—Sir W. E. Logan and James Hall.

Besides the forms described in the preceding pages, there are several others belonging to the genus *Graptolithus*, of which I have not specimens in sufficient perfection to furnish a proper description; and there are others which, possessing some abnormal characters, I hesitate to describe as distinct species, until I shall have an opportunity of seeing more specimens. One of these, having the general character of *G. octobrachiatus*, has but seven branchlets, three from one extremity of the vinculum and four from the other, bifurcating as in the species named above. The branches, however, are more slender than in *G. octobrachiatus*, and it may prove to be a distinct species.

Another form having the general habit of *G. Logani* has but nine branchlets, four from one and five from the other side of the vinculum. The exterior side only is visible, and the branches being broken off a short distance from the vinculum, no opportunity is offered of examining the serratures. It seems quite probable that this may prove a distinct species.

A single fragment of a ramose form, with two branches like *G. ramosus*, of New York, has been observed, but I have not thought it desirable to give its characters at present.

Among other forms of the *Graptolitidea*, there are at least three species of *Dictyonema*, which are of common occurrence, associated with the Graptolites of Point Lévy.

The genus *Dictyonema* was described in the Palæontology of New York, vol. 2, p. 174, from an examination of the broad flabelliform or sub-circular expansions of corneous reticulated fronds common in the shales of the Niagara group. These forms were described as having " the appearance and texture of Graptolites, to which they were doubtless closely allied," Further examinations have demonstrated the truth of this remark in the discovery of serratures, like those of *Graptolithus*, on the inner side of the branchlets of both *D. retiformis* and *D. gracilis*. The celluliferous side adhering more closely to the stone than the opposite, as in *Retepora* and *Fenestella*, is much more rarely seen than the other. The mode of growth, though probably flabelliform in some species, is clearly funnel shaped in *D. retiformis*, the serratures being upon the inner side as in *Fenestella*.

The generic characters heretofore given may therefore be extended as follows.

DICTYONEMA.

Generic characters.—Frond consisting of flabelliform or funnel-shaped expansions, (circular from compression) composed of slender radiating branches, which frequently bifurcate as they recede from the base ; branches and subdivisions united laterally by fine transverse dissepiments; exterior of branches strongly striated and often deeply indented; inner surface celluliferous or serrate, as in *Gruptolithus*.*

The general aspect of the species of this genus is like that of *Fenestella*, both in the form of the fronds and the bifurcation of the branches. Some of the species have hereto-

* A paper by J. W. Salter, Esq., Palæontologist of the Geological Survey of Great Britain, read before the American Association, for the advancement of Science, at the Montreal Meeting, 1857, describes a new genus of the Graptolite family under the name of *Graptopora*. Athough having had no opportunity of examining this paper, it appears to me that the forms described are true *Dictyonema*.

fore been referred to that genus, and others to *Gorgonia*. They may be known from either of these genera by the striated and serrated corneous skeleton, and absence of round cellules, which latter character, with a calcareous frond, marks the *Fenestella*.

Since the essential characters of *Dictyonema*, with figures of two species, have been given long ago, and their similarity to Graptolites pointed out, I am disposed to retain the name, and to describe the Canadian species under that designation.

There are still two other types in this collection which seem to merit generic distinction. One of these consists of imperfect branching fronds, the smaller branchlets of which are often rigidly divergent from the main branch at an angle of about thirty-six degrees. In others the branchlets diverge in a similar manner, but are less rigid. Exterior of branches smooth, interior surface celluliferous. There are two or three forms of this type which I propose to designate as DENDROGRAPTUS.

Another form consists of fronds which are strong stipes near the base, and become numerously and irregularly branched, ending in a great number of filiform branchlets, one side of which is serrated. The general aspect is that of a shrub or tree in miniature. For these forms I would propose the generic name of THAMNOGRAPTUS.

There is also a single species approaching in character to that published in the Report of the Fourth Geological District of New York as *Filicites?* The lateral branchlets are much longer, more lax and slender, being in this respect more nearly like *Filicites gracilis* of Shumard, (Geol. Report of Missouri, part 2, p. 208, pl. a. fig. 11) but the branchlets in the Canadian species are longer and more slender. They have all the same general plumose character, and from the well preserved corneous structure in the Canadian specimens, I regard them as belonging to the Graptolitideæ, although the celluliferous or serrated margins have not been seen. For these forms of Canada, New York and Missouri, should they prove generically identical, I propose the name of PLUMALINA, making the *Filicites?* cited above, the type of the genus with the name of *Plumalina plumaria*, while the western species will receive the name of *P. gracilis*.

The disk-like forms which are described in the Palæontology of New York, vol. 1, p. 277, under the name of *Discophyllum*, are probably the disks of a species of *Graptolithus* with numerous branches. One specimen preserves a thick corneous substance, which is the exterior surface, while the other preserves the mould of the opposite side, the radiating impressions of which are crenulated. There are no evidences of branches extending beyond the margin of the disk.

We have now so many well-established forms in the family *Graptolitideæ*, that we have the means of comparison with other allied families among palæozoic fossils.

Although numerous species in this collection are shown to be of compound structure, or to consist of fronds composed of two or more branches, and many of them originating in, or proceeding from a disk of thickened corneous substance, yet it is not improbable that there are among true Graptolites simple stipes or stems, as all the species have been usually heretofore regarded. I am disposed to believe that those Graptolites where the stipe is serrated on the two sides (*Diplograpsus*) may have been simple from the base; and that the branching forms having both sides, or one side only of the branches serrated, may possibly also have been simple, or bearing no more than a single stipe from the radicle. The bifurcate appearance at the base of *G. bicornis* however, offers some objections to this view, and these too may have been compound, like those which have only one side serrated.

The numerous compound forms shown in this collection, and the great variety of combination in the mode of branching, induces the belief that all those with a single series of serratures have been originally composed of two, four, or more branches, either diverging from a radicle or connected by a vinculum from which the radicle has extended.

The *Phyllograptus*, although apparently an anomalous form, is not more so with our present knowledge of the Graptolites than *G. Logani* or *G. octobrachiatus* would have been considered a few years since.

It is not among the least interesting facts, that we should find the *Graptolitideæ* simulating in their mode of growth so many of the Palæozoic *Bryozoa*. We have *Fenestella*

represented in *Dictyonema*, the ramose forms of *Retepora* in *Dendrograptus*; *Glauconome* and *Ichthyorachis* in *Plumalina*; while the spirally ascending forms figured by Barrande appear to simulate in their mode of growth the spiral forms of *Fenestella* or *Archimedes*.

The forms of Graptolites now known are so numerous as to deserve especial considerations in their relations to other groups or families of fossil or living forms. They have been referred to the *Radiata* and to the *Bryozoa*. They were all originally composed of a thin corneous film which enclosed the bodies of the animals inhabiting the cells, and formed the general canal or source of communication along the axis. The substance of the Graptolites was then unlike that of the *Radiata* of the same geological age; the sub-divisions are in twos, or some multiple of two, except in a few instances which appear to be abnormal developments; and when the sub-divisions are irregular there is far less similarity with *Radiata*.

From all Palæozoic *Bryozoa* the Graptolites differ essentially in the form and arrangements of the cellules, and the nature of the substance and structure of the skeleton; and simulate only the general forms of Bryozoan genera.

JAMES HALL.

REPORT

FOR THE YEAR 1857,

OF

E. BILLINGS, ESQ., PALÆONTOLOGIST,

ADDRESSED TO

SIR W. E. LOGAN, F.R.S.,

DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

MONTREAL, 1*st March*, 1858.

SIR,

During the time which elapsed between the date of my last report and the 1st of last September, I was principally employed in the arrangement of the Museum, a work which had then become sufficiently advanced to permit of my taking the field for the remainder of the season. Under your instructions therefore, I ascended the Ottawa and Bonne-chere rivers, for the purpose of collecting specimens and investigating some points bearing upon the grouping of the organic remains in the Black River and Trenton limestones, as well as noting the distribution of these formations wherever they might be met with in the district to be examined.

Having proceeded up the Bonne-chere to the village of Eganville, I there engaged Mr. J. McMullen, whose extensive knowledge of the geographical features of that region I found would be of much service, to accompany me for a few days. At the lumbering depot of Messrs. Egan & Co. we procured a supply of provisions, and Messrs M. & J. Hickey obligingly furnished us with camping utensils. I then visited Lake Clear, in the newly surveyed township of Sebastopol, and was engaged in that neighbourhood seven days. During my examinations, I received much information from T. P. French, Esq., the Go-

vernment agent for the settlement of the Crown lands upon the Opeongo road. Mr. French hospitably entertained us for two nights, and did all in his power to further the objects which I had in view.

After leaving Lake Clear I returned to Eganville, and ascended the river to Golden Lake, the shores of which I examined, and then made an excursion from the south side through the woods nearly to the hills presently to be mentioned. I then returned to the Fourth Chute, and was fortunate in arriving there at a time when the channel of the river was laid nearly dry in consequence of the water being cut off by the closing of the feeding apparatus of the slide at the foot of Mud lake. I had made arrangements to have this effected, but as it was also required by the workmen engaged in the construction of a bridge at Eganville, the water was shut off without being done on my account.

After examining the section at the Fourth Chute, and making a collection of fossils, I returned to Montreal. The following are the observations made during this expedition;

Lake Clear.

This lake is about six miles in length, and extends diagonally nearly across the northern half of the township of Sebastopol, its direction being about W.N.W. and E.S.E. It is of an oblong-oval shape, and three miles across in its widest part. There are fifteen small islands in it, lying principally at the south-east end. The south shore rises with a somewhat rapidly increasing slope from the water's edge, until it attains a height of from one hundred to three hundred feet. Viewed from the north shore this high land appears to be a ridge of hills or mountains, but on crossing over it is found not to be too steep towards the lake to interfere materially with cultivation, and accordingly séveral good farms have been there commenced. The timber is principally hardwood on the south and east shores, but on the north and east spruce and pine.

On the north side there are several smaller lakes connected with the principal one by small creeks. In these I found that

extensive deposits of shell marl were in the progress of accumulation. The fresh water mollusca from whose shells these valuable deposits are being formed, I ascertained to be *Physa heterostropha* (Say), *Planorbis campanulatus* (Say), *P. bicarinatus* (Rackett), *Paludina decisa* (Say), and *Cyclas orbicularis ?* (Say). There were also two species of Naiades, the widely distributed *Unio complanatus* (Lea), and *Anodon fluviatilis* (Lea). While coasting round the lake I saw hundreds of these two, but none of the others so common in the Ottawa. The same fact was observed with respect to their distribution in Golden Lake, but at the Fourth Chute of the Bonne-chere, *Margaritana marginata* (Lea), and *M. rugosa* (Lea), were seen.

The marl however consists almost altogether of the shells of the species of gasteropoda above mentioned, and as the living specimens do not appear to be more numerous in the lake than they are upon the shores of some of the rivers of the country, it must have required a great length of time for their remains to accumulate to the depth of several feet, which is often attained by these beds of marl.

The lake abounds with fish, the most abundant species being the Perch, *Perca flavescens* (Cuvier), the Sun-fish, *Pomotis vulgaris* (Cuvier), the Rock-bass, *Centrarchus æneus* (Cuvier), the Pike, *Esox reticulatus* (Lesueur), and the Salmon-trout, *Salmo namaycush* (Pennant). This latter species during the spring and summer months, according to the information I received from the settlers, retires to the deepest parts of the lake, and is rarely seen in shallow waters, but in the month of October it appears upon the shoals in vast numbers, the bottom being sometimes literally covered with them. They are then easily captured, and in such quantities that one of the inhabitants is in the habit of feeding his pigs with them. The method of taking them is by spearing at night from a canoe, the light used being a torch of the roots of the pitch pine or the bark of the white birch. Several barrels have been taken in one night by a single party.

The formations observed in the neighbourhood of Lake Clear are the Laurentian and Trenton. The former occupies the whole of the north and east shores, and a portion of the south

shore; all the islands consist of Laurentian rocks. The Opeonga road runs nearly parallel with the lake, at a distance of from half a mile to one mile and a-half from the south shore. Following this road through the township of Sebastopol, numerous exposures of gneiss were observed, but no Silurian limestones except in scattered blocks, which by their included fossils were ascertained to have been in general derived from some deposit of the age of the Black River. At Eganville, distant about ten miles, there is, as stated in former reports, an outlier of this rock, but it is situated at a level three hundred feet below some of the hills upon which these boulders are now found. If they have been derived from this outlier, this locality affords a good example of the transport of boulders from a lower to a higher level.

The rock exposed on the road consists of different varieties of gneiss, with no crystalline limestone except in one locality, lot 53, where a one-foot bed was seen. The gneiss in numerous places where I examined it has a dip of about 45° towards the north-east. This appears to be the prevailing dip from Renfrew to Golden Lake, a distance of forty miles. White crystalline limestone occurs at the south east end of the lake, but in no great quantity. It is there interstratified with the gneissoid rocks.

In order to ascertain the distribution of the Silurian limestone mentioned in Mr. Murray's Report of 1853, I coasted along the south shore of the lake in a canoe, starting from lot No. 49 which is occupied by Mr. French. The whole of the shore east of this point is occupied by the Laurentian formation. Proceeding westerly no exposures of rock in place were seen until at the distance of about one mile from lot No. 49, I found the Trenton limestone at the water's edge. There were only two beds visible, each about six inches in thickness. Half a mile further west another small exposure was found, which like the former, is at the water's edge. The only fossils seen were *Strophomena alternata* (Conrad), *Leptæna sericea* (Sowerby), and *Pleurotomeria umbilicata*, (Hall). Further on in the same direction on lot No. 16 in the tenth range, at Michael Mulroy's clearing, the same rock occurs in place at

the water's edge. The shore here rises to the height of eighty feet, and is no doubt an ancient cliff of Trenton limestone, as the whole face of the hill is a mass of angular fragments of that rock. The fossils are *Petraia corniculum* (Hall), *Monticulipora dendrosa* (Billings), *Leptæna sericea* (Sowerby), *Strophomena alternata* (Conrad), *Orthis testudinaria* (Dalman), *Bellerophon bilobatus* (Sowerby), *Murchisonia bellicincta* (Hall), *Pleurotomaria umbilicata* (Hall), *Oncoceras constrictum* (Hall), *Asaphus gigas* (Dekay), *Illænus* ———, *Heterocrinus Canadensis* (Billings.)

With a view of ascertaining how far the limestone might extend back from the lake I ascended the hill and proceeded in a southerly direction. At the distance of about four hundred yards from the shore there is a terrace of drift, the top of which is estimated to be one hundred and fifty feet above the first terrace. Then succeeds a flat space, with but a gentle rise for five hundred paces, when we come to a cliff of gneiss running parallel with the lake. This cliff is a portion of the ridge of hills which runs the whole length of the lake, and is continued further on in the same direction beyond Golden Lake. No limestone was found west of Mulroy's clearing on the lake shore, the land at that end being low and exhibiting no exposures of rocks of any kind.

It appears therefore to be quite certain that the fossiliferous rocks at Lake Clear are confined to a narrow strip, not more than five hundred yards in width, extending along the south shore from within a mile of lot. No. 49, westerly.

But, although on the south shore its limits are thus confined, there can be but little doubt that the limestone underlies the flat land at the west end of the lake, and extends three or four miles further. In that direction I found the land in many places covered with fragments of the rock, and on lot No. 7 in the fourteenth concession, occupied by John Ryan, there is a small exposure which appears to be at the base of the Trenton. The fossils are *Monticulipora petropolitana* (Pander), *Orthis tricenaria* (Hall), *Strophomena alternata* (Conrad), *S. filitexta* (Hall). Beyond this point no other exposure of the rock could be found.

At Golden Lake there are some indications of Silurian rocks at a point on the north shore about two miles west of Mr. Thomas's house, which is situated at the eastern extremity of the lake. Fragments of an argillaceous limestone are there seen abundantly along the shore, presenting all the characters of having been derived from underlying beds, and I was informed that in low water, about half a mile from the shore opposite this point, the bottom can be seen to be composed of the same material. It resembles some of the beds of the Chazy, and probably forms the bottom of much of the lake. Elsewhere the shores and surrounding lands are all of the Laurentian formation wherever rock can be seen in place. The ridge of high land which passes along the south of Lake Clear runs also past the south side of Golden Lake, but at the distance of about four miles from the shore. The intervening space is partly swampy land, and in part, consists of low hills of gneiss for at least two miles, which is as far as I proceeded in that direction.

The Fauna of the Black River Limestone of Canada compared with that of the same formation in the State of New York.

While preparing the first volume of the Palæontology of New York, Professor Hall found that in the Potsdam sandstone three species were then known, which were strictly confined to that formation. The several species of *Protichnites* published by yourself and Professor R. Owen of London in the Journal of the Geological Society, have as yet only been seen in the same rocks.

In the Calciferous sand-rock Professor Hall found thirteen species, only one of which passed upwards into succeeding strata; in the Chazy limestone forty-five species, all except one confined to this rock; in the Bird's-eye limestone nineteen, one of these passing upwards. In the Black River limestone thirteen, and out of these three were also found in the Trenton limestone.

Out of the seventy-seven species found in the Chazy, Bird's-eye and Black River limestones, only three pass the line be-

tween the last-mentioned and the Trenton in the State of New York. These formations have been therefore very properly described as almost totally distinct from each other in that country. In Canada, however, the case is very different. The discovery of the connection between the Black River and Trenton limestones was first made by yourself, and communicated to the British Association at their meeting, held at Ipswich in July, 1851. On that occasion Mr. Salter, Palæontologist to the Geological Survey of Great Britain, also read a paper on the fossils collected at Pauquette's Rapids on the Ottawa, which confirmed your previously expressed views. Since that time a great deal of additional evidence has been accumulated, and one of the objects of my visit to the Bonne-chere was to ascertain if the same intermingling of the fossils could be observed in the exposures of the rock on that river.

The locality most specially examined is at the Fourth Chute, near Mr. C. Merrick's mill, where Mr. Murray measured the section published in his report for 1854, pages 96 and 97. The strata of limestone and shale there exposed are in all forty-six feet in thickness and well charged with fossils. The lowest bed visible at low-water mark on the south side of the stream at the foot of the timber slide, holds *Columnaria alveolata*, *Stromatocerium rugosum*, *Ormoceras tenuifilum*, and *Orthoceras multitubulatum* of the Black River limestone. This bed is continued across the channel and forms the base of the cliff on the North side opposite the foot of the slide. From this level up to the mouth of the cave through which the water flows to Mr. Merrick's mill there are about thirty-five feet in thickness of shales and limestone in which the following species of fossils occur.

1.	*Calumnaria alveolata*	(Goldfuss).	Black River.
2.	*Stromatocerium rugosum*,	(Hall).	Black River.
3.	*Monticulipora dendrosa*	(Billings).	Trenton.
4.	*Glyptocrinus priscus*	(Billings).	
5.	*Columns of Thysanocrinus.*		
6.	*Orthis gibbosa?*	(Billings).	
7.	——— *insculpta*	(Hall).	Trenton.
8.	——— *tricenaria*	(Conrad).	Trenton.

9.	*Strophomena alternata*	(Conrad).	Trenton.
10.	*Rhynconella increbescens*	(Hall).	Trenton.
11.	———— *bisulcata*, ...	(Emmons).	Trenton.
12.	*Eichwaldia subtrigonalis*, ...	(Billings).	
13.	*Vanuxemia inconstans*, ...	(Billings).	
14.	*Cyrtodonta Canadensis*, ...	(Billings).	
15.	*Raphistoma staminea*	(Hall).	Chazy.
16.	*Pleurotomaria subconica*	(Hall).	Trenton.
17.	———— *umbilicata*	(Hall).	Trenton.
18.	*Murchisonia gracilis*	(Hall).	Trenton.
19.	———— *bicincta*	(Hall).	Trenton.
20.	———— *ventricosa*	(Hall).	Trenton.
21.	———— *perangulata*	(Hall).	Birdseye.
22.	*Subulites elongatus*	(Emmons).	Trenton.
23.	*Orthoceras bilineatum*	(Hall).	Trenton.
24.	———— *multitubulatum*, ...	(Hall).	Black River.
25.	———— *tenuifilum*, ...	(Hall).	Black River.
26.	*Illaenus arcturus*	(Hall).	Chazy.
27.	*Phacops callicephalus*, ...	(Hall).	Trenton.
28.	*Cheirurus pleurexanthemus*, ...	(Green).	Trenton.
29.	*Acidaspis? spiniger*	(Hall).	Trenton.

In the above list all the species marked Chazy, Birdseye or Black River, are confined to these formations in the State of New York with the exceptions of *Pleurotomaria umbilicata* and *Monticulipora dendrosa*. The former occurs in both the Birdseye and Trenton in New York, and the latter which is the same as the branched form of *Chætetes lycoperdon* ranges from the Calciferous upward, perhaps to the Upper Silurian. Those marked Trenton do not occur below that formation in New York, although some of them are found in higher groups. The new species in the above list have been seen in Canada in the Black River only. The list contains sixteen Trenton limestone species, four of the Black River, one of the Birdseye, and two of the Chazy, besides three new species as yet confined to the Black River and one, *Glyptocrinus priscus*, which occurs also in the Trenton. The columns of *Thysanocrinus* appear to be those of *T. pyriformis*.

Orthis gibbosa is a species described by me under that name in last year's Report, but having since received from Dr. Shumand a very perfect specimen of *O. subæquata* (Conrad) from the Hudson River group at Cincinnati, I find upon comparison that the two forms are almost identical, and I have there-

fore marked it doubtful. I have never seen it in the Trenton.

Orthis insculpta.—The specimens are in no respect distinguishable from those of the Hudson River group, except that the dorsal valve exhibits a slight mesial depression. It occurs in the Trenton in Canada.

Raphistomea staminea.—The specimens vary much in the proportional depth and breadth as well as in the amount of the elevation of the spire and sharpness of the outer edge.

There are several species of Bryozoa, one of which appears to be *Stictopora fenestrata* of the Chazy and another *S. ramosa.*

From the mouth of the cave up to the top of the section, there is, including the large flat exposure above the bridge, a thickness of about twelve feet consisting of limestones and shales. In this part of the section the fossils are more numerous and their state of preservation is precisely that exhibited by specimens collected at Pauquettes Rapids and Lake St. John. The grouping of the species is also the same as at Pauquettes Rapids. Above the bridge on the shore of the river and in the neighbouring fields a large proportion of all the species that have been found in the Black River in Canada were either collected or observed in place. As they will all be given in the next list it is not necessary to enumerate them separately, and I shall not therefore designate them here.

It would be very difficult to decide by mere fossil evidence whether the rocks at this locality should be classified as belonging to the Trenton limestone, or to the Black River formation. If we call them Trenton, then we must suppose that the fauna of the Black River age, after becoming extinct in other places, lingered on for a while in this spot, until the Trenton period had become well advanced. But if these rocks are to be called Black River, then the Trenton species were introduced here in advance of the period usually assigned for their appearance in the Silurian seas. Such would be the only explanation that could be given, if the line between these formations so strongly defined in New York, is to be regarded as a good natural horizon of separation. If on the other hand, it be granted that the Black River and Trenton fossils constitute but one zoological group, then of course, a

great portion of the difficulty would be removed, the only question remaining being to decide upon a name for the formation.

The following is a list of fossils found in the beds which hold the characteristic species of the Black River limestone in Canada, all new forms not known to occur in the Trenton, and all species not clearly identified being excluded. A list shewing the number of Trenton species which occur in the Chazy is in preparation.

! Signifies common, !! abundant.

			Position in New York.
1.	*Tetradium cellulosum!!* (Hall sp.) This is the *Phytopsis cellulosum* of the Paleontology of New York. Professor Safford has shewn that these species belong to the Genus *Tetradum* of Dana; *T. fibratum* (Safford) of the Lower Silurian of Tennessee is closely allied to ours, and I should not be surprised if it should be found identical. [See Safford's paper on *Tetradium*, *Silliman's Journal*, 2d series, vol. 22, page 236.]		Birdseye.
2.	*Columnaria alveolata*	(Goldfuss)	Black River.
3.	*Monticulipora dendrosa*	(Billings)	Trenton.
4.	*Petraia profunda!*	(Hall sp.)	Black River.
5.	——— *corniculum!*	(Hall sp.)	Trenton.
6.	*Receptaculites occidentalis!*	(Salter)	Trenton.
7.	*Stromatocerium rugosum*	(Hall)	Birdseye and Black River.
8.	*Glyptocrinus priscus* (Billings). This species is not reported as occuring in New York. The only perfect head was found by myself in the mouth of the cave in the Bonnechere section several years ago. I have ascertained its existence in the Trenton in Canada.		
9.	*Strophomena alternata*	(Conrad)	Trenton.
10.	——— *filitexta!!*	(Hall)	Trenton.
11.	*Leptæna sericea*	(Sowerby)	Trenton.
12.	*Orthis testudinaria*	(Dalman)	Trenton.
13.	——— *gibbosa?*	(Billings)	
14.	——— *insculpta!*	(Hall)	Trenton.
15.	——— *tricenaria*	(Conrad)	Trenton.
16.	*Rhynconella increbescens!*	(Hall)	Trenton.
17.	——— *recurvirostra!*	(Hall)	Trenton.
18.	——— *bisulcata*	(Emmons),	Trenton.
19.	*Ctenodonta levata*	(Hall)	Trenton.
20.	——— *nasuta!!*	(Hall)	Trenton.
21.	——— *gibbosa*	(Hall)	Trenton.
22.	——— *dubia!!*	(Hall)	Trenton.
23.	*Euomphalus uniangulatus!!*	(Hall)	Calciferous.

This species occurs in the Calciferous sandrock, Black River and Trenton limestones in Canada.

24. *Raphistoma staminea* (Hall) .... Chazy.
25. *Maclurea Logani*.............................(Salter),
26. *Pleurotomaria lenticularis !*....................(Hall), Trenton.
27. ————————*rotuloides* ....(Hall), Trenton.
28. ————————*umbilicata ! !* ....(Hall), Trenton.

Occurs also in theBlack River in New York.

29. ————————*subconica !*......................(Hall), Trenton.
30. *Murchisonia bicincta !* ....(Hall), Trenton.
31. ————————*tricarinata !*.....................(Hall), Trenton.
32. ————————*ventricosa !*......................(Hall), Birdseye.

Occurs in the Trenton in Canada.

33. ————————*perangulata* ....(Hall), Birdseye.
34. ————————*bellicincta !*......................(Hall), Trenton.
35. ————————*gracilis ! !*.........................(Hall), Trenton.
36. ————————*subfusiformis* ....(Hall), Trenton.
37. *Subulites elongatus !*..........................(Emmons), Trenton.
38. *Bellerophon sulcatinus !*.......................(Emmons), Chazy.
39. ————————*rotundatus !* ....(Hall), Chazy.
40. ————————*bilobatus !* ....(Sowerby), Trenton.
41. ————————*expansus !* ....(Hall), Trenton.
42. ————————*bidorsatus !* ....(Hall), Trenton.
43. ————————*punctifrons !* ....(Emmons), Trenton.
44. *Crytolites compressus*..........................(Conrad Sp.), Trenton.
45. *Orthoceras (Ormoceras) tenuifilum* ....(Hall), Black River.
46. ————————*multicameratum* ....(Conrad), Birdseye.
47. ————————*recticameratum* ....(Hall), Birdseye.
48. ————————*fusiforme* ....(Hall), Birdseye.
49. ————————*arcuoliratum ! !* ....(Hall), Trenton.
50. ————————*bilineatum !* ....(Hall), Trenton.
51. ————————*anellum !*..........................(Conrad), Trenton.
52. ————————*amplicameratum*...................(Hall), Trenton.
53. ————————*strigatum* ....(Hall), Trenton.
54. ————————*laqueatum* ....(Hall), Trenton.
55. ————————*Allumettense !* ....(Billings), Trenton.
56. ————————*Ottawaense ! !* ....(Billings), Trenton.
57. ————————*hastatum !* ....(Billings), Trenton.
58. ————————*decrescens !*.......................(Billings), Trenton.
59. ————————*Huronense !* ....(Billings), Trenton.

The five last mentioned species are common in the Trenton and Black River in Canada and *O. Allumettense* is also found in the Chazy sandstone at Aylmer and Hawkesbury.

60. *Gonioceras anceps*..............................(Hall), Black River.
61. *Orthoceras subcentrale*.........................(Hall), Black River.
62. ————————*longissimum*......................(Hall), Black River.
63. ————————*multitubulatum*...................(Hall), Black River.

64.	————————*annulatum*	(Hall),	Trenton.
65.	*Oncoceras constrictum !*	(Hall),	Trenton.
66.	*Cyrtoceras annulatum*	(Hall),	Trenton.
67.	————————*macrostomum*	(Hall),	Trenton.
68.	————————*multicameratum*	(Hall),	Birdseye.
69.	*Lituites undatus*	(Emmons),	Black River.
70.	*Asaphus extans*	(Hall),	Birdseye.
71.	*Illænus arcturus ! !*	(Hall),	Chazy.
72.	*Ceraurus pleurexanthemus*	(Green),	Trenton.
73.	*Phacops callicephalus*	(Hall),	Trenton.
74.	*Illaenus ovatus !*	(Conrad),	Trenton.
75.	*Acidaspis ? spiniger*	(Hall),	Trenton.

In the above list we have sixteen species given as occurring in the Birdseye or Black River limestones of New York, forty-four of the Trenton, four of the Chazy and one of the Calciferous. (There are six new species known to occur in both Black River and Trenton in Canada and two only known in the Black River.) Out of seventy-five species, fifty-two are common to the two formations. Besides these there are about thirty others known to pass from the Black River into the Trenton, part of which are new and undescribed, while the others appear to be the same as some of those figured in the first volume of the Palæontology of New York.

On the other hand however, we have about eighty species of *Echinodermata*, consisting of *Cystideæ*, *Crinoideæ* and *Asterideæ* in the Trenton, not yet found in the Black River. As these fossils however are thought to have a very limited vertical range they do not materially affect the main question, whether the Black River and Trenton limestones were deposited during a period in which the bulk of the fauna remained unchanged, and in which there occurred no catastrophe such as an almost total destruction of life, immediately followed by a new creation.

The Fauna of the Black River Limestone of Canada compared with that of the Lower Silurian of Tennessee.

The lists of fossils published by Professor Safford of Tennessee bear directly upon this subject, and as they may be of service to those studying geology in Canada, I beg to transcribe

them into this report.* The Lower Silurian limestones of Middle Tennessee are about five hundred feet thick and are divided into two principal groups.

1. The Stones River Group from 240 to 260 feet in thickness. This division corresponds to the Black River and Trenton formations of Canada.

The lowest seventy-five feet of this formation consists of "blue and brownish-blue limestones, mostly fine grained and thick bedded, some of the strata of which abound in dark flinty layers." They are called the *Stones River beds*, and contain the following fossils :—

1.	*Stromatocerium rugosum*	(Hall),	Black River.
2.	*Orthis bellarugosa*	(Conrad),	Trenton.
3.	*Atrypa hemiplicata*	(Hall),	Trenton.
4.	" *recurvirostra ?*	(Hall),	
5.	*Leptæna incrassata.*		
6.	*Pleurotomaria umbilicata*	(Hall),	Black River & Trenton.
7.	*Gonioceras anceps*	(Hall),	Black River.
8.	*Actinoceras tenuifilum*	(Hall),	Black River.

Excluding the doubtful forms, there are in this list three Black River species, two Trenton, and one which is both Black River and Trenton.. They are all found in the Black River in Canada.

Above these beds Professor Safford says there are from fifty to sixty feet of thin bedded "sky-blue layers, sometimes separated by seams of argillaceous matter." They are "coarsely crystalline and abound in calcareous remains." The fossils are :—

1.	*Chætetes*, new species ! ! allied to *Lycoperdon*.		
2.	" *?* new species.		
3.	*Trematopora*, two new species.		
4.	*Stictopora ! !* four or five new species.		
5.	*Retepora fenestrata*	(Hall),	Chazy.
6.	*Escharopora*, new species.		
7.	*Graptolithus amplexicaulis*	(Hall),	Trenton.
8.	*Schizocrinus*, new species.		

* *The Silurian Basin of Middle Tennessee, with notices of the Strata surrounding it;* by James M. Safford, A.M., Prof. of Chemistry and Geology, Cumberland University, Lebanon, Tenn. Silliman's American Journal of Science, Vol. xii., 2nd series, page 352.

9. *Fragment of a cystidean*, new genus.
10. " *of a Sphæronite*, new species.
11. *Stems of Cystideæ.*
12. *Leptæna incrassata ! !* .... (Hall), Chazy.
13. " *sericea* .... (Sowerby), Trenton.
14. " *filitexta* .... (Hall), Trenton.
15. " three species, new and undetermined.
16. *Orthis deflecta ! !* .... (Conrad), Trenton.
17. " *subæquata ! !* .... (Conrad), Trenton.
18. " *perveta* .... (Conrad), Trenton.
19. " *tricenaria !* .... (Conrad), Trenton.
20. " *belldrugosa* .... (Conrad), Trenton.
21. " ———? allied to *O. disparalis.*
22. *Atrypa increbescens ?*
23. ——— allied to *A. recurvirostra.*
24. *Ambonychia amygdalina* .... (Hall), Trenton.
25. " *obtusa* .... (Hall), Trenton.
26. *Edmondia ventricosa* .... (Hall), Trenton.
27. *Maclurca magna* .... (Lesueur), Chazy.
28. *Pleurotomaria umbilicata* .... (Hall), Trenton & Black River.
29 ———— *subconica* .... (Hall), Trenton.
30. ———— *lenticularis* .... (Sowerby), Trenton.
31. *Subulites elongatus !* .... (Emmons), Trenton.
32. *Holopea*, new species.
33. " ———? allied to *H. obliqua.*
34. *Murchisonia bicincta !* .... (Hall), Trenton.
35. *Cyrtolites compressus* .... (Conrad), Trenton.
36. *Bucania bidorsata* .... (Hall), Trenton.
37. ——— *expansa* .... (Hall), Trenton.
38. *Carinaropsis*, new species.
39. *Endoceras proteiforme !* .... (Hall), Trenton.
40. ——— new species.
41. *Orthoceras fusiforme !* .... (Hall), Black River.
42. ——— *multicameratum ?*
43. ——— *undulostratum ?*
44. *Actinoceras tenuifilum !* .... (Hall), Black River.
45. *Gonioceras anceps* .... (Hall), Black River.
46. *Oncoceras constrictum* .... (Hall), Trenton.
47. *Lituites ?* new species.
48. *Cyrtoceras*, allied to arcuatum .... (Hall).
49. *Cytherina fabulites ! ! !* .... (Conrad).
50. *Ceraurus pleurexanthemus* .... (Green), Trenton.
51. *Calymene Blumenbachii ! !* Trenton.
52. *Illaenus ovatus* .... (Conrad), Trenton.
53. ——— species ?
54. *Phacops callicephalus* .... (Hall), Trenton.
55. *Isotelus megistos.*
56. *Tail of Lichas.*

This list contains three Chazy species, three Black River species, twenty-four Trenton species, and one common to the Black River and Trenton.

There are eight Trenton species which have not yet been found in the Black River in Canada, but in Canada we have in this rock twenty-eight Trenton species not given in these lists as occurring in Tennessee.

This last list contains the fossils of that part of the Stones-River group which Prof. Safford calls the *Lower Lebanon limestone.* The next beds in the ascending order called the *Upper Lebanon limestone*, are from one hundred and ten to one hundred and thirty feet thick, consisting of brownish-blue thick-bedded strata, with about twenty feet of thin beds interstratified occasionally with seams, and rarely beds of clay. Fossils are not very abundant, but "the middle portion of the member is everywhere characterised by groups of silicified *Columnaria alveolata*, *Streptelasma profunda* (Hall), and the rough spherical masses of *Stromatocerium rugosum*, to which we may add *Actinoceras tenuifilum*." The following species occur in this group:—

1. *Stromatocerium rugosum ! !*................................Hall.
2. *Columnaria alveolata ! !*..................................Goldfuss.
3. *Astrocerium*, new species.
4. *Chætetes lycoperdon ?*.....................................Say.
5. " *columnaris*..Hall.
6. *Streptelasma profunda*.....................................Hall.
7. *Clathropora*, species undescribed.
8. *Stictopora*, two new species.
9. *Atrypa recurvirostra*......................................Hall.
10. *Leptæna filitexta*..Hall.
11. *Pleurotomaria rotuloides*.................................Hall.
12. ——— ——— *subconica*......................................Hall.
13. *Murchisonia bicincta*.....................................Hall.
14. *Actinoceras tenuifilum ! !*
15. *Orthoceras anellum ?*
16. ———— *multicameratum ?*

It is evident from this list and from the remarks of Professor Safford, that the Upper Lebanon rocks are more strongly marked with a Black River fauna than the Lower Lebanon formation, while the latter is characterized principally by Trenton species. In fact we have here a Trenton formation

lying below a group of rocks which in Canada or New York would be called Black River, provided we are to designate as such all rocks holding *Columnaria alveolata* and *Stromatocerium rugosum.*

Such groupings as these show the immense importance of obtaining many other lists of fossils from localities widely separated from those already examined. Otherwise in mapping a new country, large tracts may receive a colour that must be afterwards removed.

But although there is in Canada this intermingling of forms characteristic of the two groups, there has, thus far, been no confusion, because in all instances where the transition can be observed, the Black River strata pass upwards into a group three hundred or more feet in thickness, exclusively charged with Trenton forms. It is easy therefore to determine which is the lower or upper part of the group, even should the Black River and Trenton be regarded as characterised in a general way by the same fauna. In Tennessee, on the other hand, the Trenton limestone appears either not to have been deposited, or if deposited at all it was during the Black River period, because the Upper Lebanon formation is followed immediately by strata charged with fossils of the Hudson River age.

Galt Limestone, Onondago and Corniferous Limestones, &c.

On the 9th October last I left Montreal for the purpose of examining the limestones in Western Canada, in which work I was engaged until the middle of November. The weather, during a part of the time, was very unfavourable, and I did not accomplish all the objects I had in view. I spent one week in the neighbourhood of Trenton, Belleville, and Shannonville, in the County of Hastings, collecting fossils, and then proceeded by the Grand Trunk Railway to Guelph and Galt, thence to Dundas, Hamilton, Thorold, Port Colborne and Cayuga. In all these places I made collections, but as a great many of the species are either new, undescribed, or difficult

of determination without comparison with European specimens, it is thought advisable not to report upon them until they shall have been further examined.

The principal object of the expedition being to examine the organic remains of the country, not much attention was given to physical geology. Of the facts observed the following are some of the most important.

Rocks at Port Colborne.—The Welland Canal as it approaches Lake Erie has a direction nearly north and south for a distance of seven miles before it reaches the turn near Port Colborne, called Rama's Bend. Throughout this distance it has been excavated in a level clay country, no rock cuttings having occured in the construction of the work. At Rama's Bend, which is about two miles distant from the Lake, the first rocks were met with. On the east side, opposite the bend, the land rises fifteen or twenty feet above the level of the canal, and displays several quarries of an impure nodular limestone, with a few fossils in the face of the slope. In the banks of the canal no exposure of rock is to be seen above the level of the water. Between Rama's Bend and the railway, a distance of about a mile-and-a-half, there are large quantities of rock among the material thrown out of the excavation and placed on the west bank of the canal. Upon inquiry I found that this had been taken from a cutting through the rock to a depth amounting on an average to fifteen feet. The fossils and the nature of the rock shew that this excavation has been made through strata which form the junction between the Onondaga Salt Group and the Onondaga and Corniferous Limestones. As however the strata were altogether beneath the water at the time of my visit, the only opinion which I could form as to their character was necessarily based upon the examination of the *debris* upon the shore.

At Rama's Bend this consists of three kinds of rock, a blue stone with numerous irregular cavities. Proceeding towards the lake from this point in the first hundred yards, we find shale, a light drab water? limestone, and a dark drab lime-among the debris blocks of rock holding small masses of snowy gypsum. At the end of 200 yards the shales disappear. The

dark coloured limestone disappears at 350 yards, but the porous limestone with gypsum continues, with some limestone holding silicious nodules. At 800 yards from the bend, all the rock disappears, and the debris consists only of blue clay. At 1560 yards from the bend the rock is again heaped up on the bank, and consists of the same materials as before, with the addition of some thick beds holding numerous corals of species identical with those of the corniferous limestone.

The shales and limestone holding the gypsum belong no doubt to the upper part of the Onondaga Salt Group, and as the fossiliferous limestone evidently succeeds it, or reposes upon it in the cutting in the canal, it follows that the Oriskany sandstone is absent at this locality.

Being desirous of ascertaining whether the same succession could be found in the tract lying between the Welland canal and the Niagara river, I went to Fort Erie and after proceeding down the river about two miles made an excursion westerly until I found an escarpment of the water-lime on lot No. 5, in the 10th concession of Bertie. This outcrop strikes directly for Port Colborne and is no doubt the same as that which crosses the canal at Rama's bend; I followed it four miles and was informed that it could be traced continuously for fourteen miles in a line parallel with the lake shore and distant from it two to three miles.

After leaving Port Colborne, I proceeded to Cayuga in the County of Haldimand and spent a week in that neighbourhood. The country is in general covered with drift clay and there are few good exposures of fossiliferous rocks. The most interesting is a tract of the Oriskany sandstone situated on the town line between Oneida and Cayuga, formerly noticed by Mr. Murray. This rock I found to be abundantly stored with the characteristic fossils of the formation. The extent of the exposure has since my visit been ascertained by Mr. J. DeCew, D. P. L. S., of Decewsville, who is much interested in the study of geology. Mr. De Cew's plan shews that on the town line the sandstone occurs on the lots Nos. 46, 47, 48, 49 and 50, and the whole area exposed is only 230 acres. The locality is of much interest as being the only one known in

Western Canada, where good collections of the fossils of the Oriskany sandstone can be procured.

Many of the species which I collected in this expedition are new, and as they require much consideration, I beg to reserve them for the next Report. The following are some that I have determined during the present year.

Genus FISTULIPORA (McCoy).

(McCoy, *British Palæozoic Fossils*, p. 11.)

Generic Characters.—" Corallum incrusting, or forming large masses, composed of long, simple, cylindrical, thick-walled tubes, the mouths of which open as simple, equal, circular smooth-edged cells on the surface, and have numerous transverse diaphragms at variable distances; intervals between the tubes occupied by a cellular network of small vesicular plates, or capillary tubules traversed by diaphragms."

This genus has no radiating lamellæ, a character which constitutes the only difference between it and *Heliolites* (Dana.)

1. FISTULIPORA CANADENSIS (Billings).

Description.—Corallum forming irregular, contorted masses, or wide, flat, undulating expansions or layers from one-half of an inch to one inch in thickness, which are based upon a thin, concentrically wrinkled epitheca. Cell-tubes half a line or less in diameter, and about one line distant from each other; the mouths of the tubes protruding a little above the general surface. Transverse diaphragms thin, horizontal or flexuous, and sometimes very numerous, there being in some of the tubes three or four in half a line of the length of the tube. The intercellular tubules are polygonal, and about four in the diameter of one of the principal cells; their transverse diaphragms are well developed, usually four or five to one line of the length.

F. Canadensis differs from the other described species in the following respects:—From *F. decipiens* (McCoy) in having the cell-tubes more distant and the diaphragms more numerous, and

from *F. minor* (McCoy) in the same particulars, the cell-tubes of the latter species being still smaller and closer together than in *F. decipiens*.

This coral much resembles *Heliolites porosa* (Goldfuss), but can be readily distinguished by the absence of the radiating septa.

Locality and Formation.—Devonian; Corniferous or Onondaga limestone; lot 6, con. 1, Township of Wainfleet; at the east end of Lake Erie.

Collector—A. Murray, Esq.

Genus COLUMNARIA (Goldfuss).

Generic characters.—Composed of large masses of elongated sub-parallel corallites, which when separate are round, but when in contact polygonal. Radiating septa either rudimentary, or well developed, sometimes reaching the centre. Transverse diaphragms numerous, usually complete, and either horizontal, oblique or flexuous.

COLUMNARIA GOLDFUSSI (Billings).

Description.—This species is found in large amorphous or sub-globose masses composed of long straight or flexuous polygonal corallites with an average diameter of about half a line; transverse diaphragms from four to six in a line; radiating septa rudimentary, but distinctly striating the interior walls.

Formation and Locality.—Hudson River group? Snake Island and Traverse point, Lake St. John.

Collector.—J. Richardson.

COLUMNARIA BLAINVILLI (Billings).

Description.—Forming large sub-globose pyriform or hemispheric masses of polygonal corallites one line and a-half in diameter; about eighteen radiating septa which reach the centre; transverse diaphragms three or four to one line.

The radiating septa in fractured specimens where the interiors of the tubes are well exposed, striate the surface exactly as in *Columnaria alveolata*, from which species and from *Favistella stellata*, Hall, it only differs by its smaller size.

Formation and Locality.—Hudson River Group. Snake Island, Lake St. John.

Collector.—J. Richardson.

COLUMNARIA RIGIDA (Billings).

Description.—Forming large masses of polygonal corallites, usually three lines in diameter, but with numerous smaller ones, and occasionally others of a larger size; radiating septa, about twenty, not reaching the centre; transverse diaphragms from two to four in one line.

This species also resembles *C. alveolata*, but differs in the greater development of the radiating septa which extend about half-way to the centre. The tubes are also about the same size as those of *Favistella stellata*, Hall, which differs in the septa not only reaching the centre, but also in their often being so strongly developed there, as to produce by their junction the appearance of a pseudo-columella.

Formation & Locality.—Hudson River group? Lake St. John.

Collector.—J. Richardson.

COLUMNARIA ERRATICA (Billings).

Description.—Forming large masses of corallites either in contact or separate. The separate cells are round, those in contact more or less polygonal, the radiating septa rudimentary, forming about four sulci in the breadth of one line upon the interior; diameter of corallites from two to five lines, in general about three and a-half lines. The transverse diaphragms are not visible in the specimens examined. The walls of the separate corallites are thick and concentrically wrinkled.

One specimen with corallites two lines in diameter appears to be a variety of this species.

Formation and Locality.—Trenton; Blue Point, Lake St. John.

Collector.—J. Richardson.

Genus PALÆOPHYLLUM, (Billings.)

Generic characters.—Corallum fasciculate or aggregate; corallites surrounded by a thick wall; radiating septa extending the whole length; transverse diaphragms either none or rudimentary; increase by lateral budding.

This genus only differs from *Petraia* or *Streptelasma* by forming long fasciculate or aggregate masses instead of being simple.

PALÆOPHYLLUM RUGOSUM (Billings).

Description.—Corallum in large aggregations of scarcely separate corallites, which where they open out upon the surface of the rock are from one to six lines in diameter, the average adult size being about four lines. Radiating septa reaching the centre; about twenty-two septa in a corallite four lines in diameter, with an equal number in a rudimentary state between.

The great disparity in the size of the tubes in the same mass is owing to the mode of increase and gradual growth of the young corallites. These, of all sizes from one line in diameter and upwards, are uniformly intermingled with the adult individuals.

Formation and Locality.—Trenton; Lake St. John, Little Discharge.

Collector.—J. Richardson.

PETRAIA RUSTICA (Billings).

Description.—Straight or slightly curved, covered with a strong epitheca, which is more or less annulated with broad shallow undulations; radiating septa about one hundred or usually a little more; much confused in the centre, where they form a vesicular mass; every alternate septum much smaller than the others, only half the whole number reaching the centre. Length from two inches and a half to three inches and a half. Diameter of cup one inch to one inch and a half; depth of cup half an inch or somewhat more.

This species appears to be the same as that described by Edwards and Haime under the name of *Streptelasma corniculum*. The true *S. corniculum* of Mr Hall is a very different species, being always shorter and much curved.

Formation and Locality.—Hudson River group; Snake Island, Lake St. John.

Collector.—J. Richardson.

Genus SYRINGOPORA (Goldfuss.)

Generic characters.—The fossils of this genus are fasciculated or composed of large aggregations of long cylindrical corallites somewhat parallel to each other and connected by numerous smaller transverse tubes. The exterior walls consist of a well developed solid epitheca; the cells circular; radiating septa rudimentary; transverse diaphragms infundibuliform or placed one within another like a series of funnels.

About twenty species of this genus are known, and these are found in the Upper Silurian, Devonian and Carboniferous formations.

SYRINGOPORA DALMANII (Billings).

Description.—Forming large masses; corallites long sub-parallel, slighly radiating, occasionally a little flexuous, annulated, one line or rather more in diameter, distant usually half a line, occasionally in contact or where flexures occur, more than one line apart; connecting processes very short, about two lines distant.

Formation and Locality.—Upper Silurian, Head of Lake Temiscaming.

Collector.—Sir W. E. Logan.

SYRINGOPORA COMPACTA (Billings).

Description.—Forming large hemispherical masses of straight parallel or slightly diverging corallites, which are so closely aggregated as to compose a nearly solid mass; about six corallites in two lines.

This species differs from all others of this genus hitherto described in the closeness of the corallites. These are so small, straight and closely united that large masses broken in the longitudinal direction of the tubes have the aspect of some species of *Monticulipora*.

Formation and Locality.—Upper Silurian. L'Ance a la Vieille, Gaspé.

Collector.—Sir W. E. Logan.

Syringopora verticilata, (Goldfuss.)

(Goldfuss, *Petr. Germ.*, vol. i. p. 76, note 25, 26.)

Description.—Forming large masses, corallites nearly straight, about two lines in diameter, and from two to three lines distant; connecting tubes three or four lines distant, verticilating, or three or four radiating from the tube at the same level in different directions, like the spokes of a wheel.

Formation and Locality.—Upper Silurian. Head of Lake Temiscaming. Goldfuss specimens were from Lake Huron.

Collector—Sir W. E. Logan.

Syringopora reteformis (Billings).

Description.—Forming large masses; corallites much geniculated, frequently anastomosing or connecting by stout processes; diameter of corallites about two-thirds of a line, distant from each other from half-a-line to a line and a-half; distance of connecting processes one line to three lines, usually about two lines.

Formation and *Locality.*—Upper Silurian. Isthmus Bay; Lake Huron.

Collector.—A. Murray.

Syringopora debilis (Billings).

Description.—Corallites a little more than half a line in diameter, distant one or two diameters; connecting processes slender, distant one or two lines.

Formation and *Locality.*—Upper Silurian; L'Anse à laVieille.
Collector—Sir W. E. Logan.

SYRINGOPORA TUBIPOROIDES, (Yandell and Shumard.)

(*Contributions to the Geology of Kentucky*, page 8; 1847.)

(M. Edwards and L. Haime, *Polypiers fossiles des terrains palæozoiques*, p. 292.)

Description.—This species is found in large masses of long slightly flexuous corallites. These have a diameter of about one line and a-half, and owing to their flexuosity, are at times in contact, and often two, three or four lines a part. In large colonies which have grown luxuriantly without the interference of disturbing causes, the corallites are more regular than in the smaller or stunted groups, in which the corallites are much bent and confused. The connecting processes are very short and distant, and appear to be sometimes mere inosculations of the stems. The corallites after growing separately for a short distance, approach each other and seem to grow together or adhere to each other for the space of a line and a-half or more, they then diverge and again unite. These points of contact occur at distances varying from three lines to six, nine, or even twelve lines. Externally they exhibit numerous other indistinct annulations, and also faint indications of longitudinal striæ.

Formation and *Locality.*—Devonian; abundant in the Corniferous limestone of Canada West.

Collectors.—A. Murray, E. Billings.

SYRINGOPORA NOBILIS (Billings).

Description.—Corallites three lines in diameter, distant two to four lines. The connecting processes in this species have not been observed, but the size of the corallites is quite sufficient to separate it from any known species.

Formation and *Locality.*—Devonian; Corniferous limestone, near Woodstock Canada West.

Collector—A. Murray.

SYRINGOPORA ELEGANS (Billings).

Description.—Corallites, one line in diameter, sometimes a little more or less, distant a little less than one line; connecting tubes half a line in diameter, and distant from one line to one line and a half, usually projecting at right angles, but sometimes a little oblique. Epitheca with numerous annulations, generally indistinct, but under certain circumstances of growth sharply defined and deep, so much so as to give to the corallites the appearance of the jointed stalk of a crinoid. The young individuals are produced by lateral budding, and in one specimen examined the whole colony appears to be based upon a broad lamellar foot secretion like that which forms the base of a Favosite.

The distance of the corallites is usually about a line, but like all the other species, this one varies a good deal in this respect. When some cause has intervened to prevent their regular growth they are much flexed and consequently at times more distant than when they have been disturbed. The connecting tubes on the same side of the corallite are three or four lines distant, but generally on the other sides one or two others in the same space occur, making the average distance one line or one line and a half.

Formation and Locality.—Devonian; Corniferous limestone, near Woodstock Canada West.

Collector—A. Murray Esq.

SYRINGOPORA HISINGERI (Billings).

Description.—This specie forms large masses of very long, nearly parallel or slightly varying, slender corallites, which are closely aggregated and present a rugged or knobby appearance from the great number of the connecting tubes. The diameter of the corallites is one-third of a line, or a little more. The tubes of connection are distant from two-thirds of a line to one line and a-half. The distance between the corallites is for the greater part less than their diameter. The young corallites branch from the sides of the adult individuals, and immediately become parallel with the parent, and connected with it again by the usual tubes of connection.

Formation and Locality.—Devonian; Corniferous limestone, Canada West. (common.)

Collectors—A. Murray and E. Billings.

Affinities of S. Hisingeri.—Edwards and Haime have described two species from Ohio, collected in rocks of the age of the Onondaga and Corniferous limestones, which appear to be closely allied to this; the following are their descriptions:

"Syringopora Verneuilli.—Corallites long, distance between them twice or thrice their diameter, subflexuous and angular at the points of the origin of the tubes of connection, these are distant two or three millimetres; diameter of the corallites two-thirds of a millimetre."—Devonian, Columbus, Ohio. (*Polypiers Fossiles*, p. 289.)

"Syringopora Cleviana.—Corallites slightly flexuous, distant once or twice their diameter, which is two-thirds of a millemetre."—Devonian, Carolton and Dayton, Ohio. (*Polypiers Fossiles*, p. 295.)

The first of these species is different from S. Hisingeri in the greater distance of the corallites. The description of the second is too incomplete to enable us to decide whether it refers to the same species or not. The authors state that their specimen was imperfect, and that they were not certain that it had not been previously described.

Genus Michelinia (De Koninck).

Generic Characters.—"Corallum compound, forming rounded, or conoidal masses of inseparably united, thick-walled, polygonal tubes of large size, marked internally with numerous vertical lamellar striæ, and communicating pores; base of cells filled up by very irregular, numerous, highly inclined vesicular plates, not forming distinct horizontal diaphragms; external or basal epitheca of the general mass, strong, concentrically wrinkled, and sometimes spinose."—*McCoy, British Palæozoic Fossils, page* 80.

This genus differs from Favosites in the vesicular character of the transverse diaphragms, and in the radiating lamellæ being represented by vertical striæ on the inner surface of the cells,

instead of series of minute spines. The cells are usually much larger than in Favosites. The genus appears to be confined to the Devonian and Carboniferous formations.

MICHELINIA CONVEXA (D'Orbigny).

(*Prodr. de Påleont.*, t. 1, p. 107, 1850.)

Description.—Corallum forming hemispherical, or erect rudely cylindrical masses, several inches in diameter; the base covered by a strong wrinkled epitheca. Adult calices from four to five lines in diameter; about forty septal striæ in each; pores small, arranged in several vertical series in some of the tubes, irregularly distributed in others; distant from half a line to more than one line. Diaphragms very convex in the centre of the tubes, and usually with three or four smaller rounded prominences on their surface; a vertical section shews that they are more vesicular at the sides of the cells than in the centre, where they are from half a line to one line and a-half distant.

MM. Edwards and Haime in their description of this species say that there are two vertical series of pores on the larger plane sides of the cells and one on the smaller. Our specimen, however shew that this is not a constant character.*

Formation and Locality.—Devonian; Onondaga and Corniferous limestones. Rama's farm, Port Colborne. Savage's quarry, lot 6, con. 1, Wainfleet. Oxford, near Woodstock and in numerous other localities in Western Canada. This species occurs in Michigan and in Preston County, Virginia.

MICHELINIA INTERMITTENS (Billings).

Description.—Corallum forming large hemispherical masses; calyces nearly equal in diameter, with periodical constrictions within at the distance of half a line to one line and a-half. Diaphragms numerous, thin, slightly convex, sometimes shewing four or five vesicular swellings upon a single surface. The septal striæ are but slightly developed, about fifty to the

* See Polypiers Fossiles des Terrains Palæozoiques, page 251.

inner circumference of the cell. Pores only visible in the intervals between the constrictions where the walls are thin, three or four series on each plane side of the tube. The cells are from three to four lines in diameter.

The constrictions give to the cells of this species a circular aspect, whereas they are in fact polygonal. I am not certain that this fossil is different from the species described by Edwards and Haime (op. cit. p. 299,) under the name of *Chonostegites Clappi.* If so it should I think be called *Michelinia Clappi,* as it exibits all the characters of Michelinia. The constrictions appear to be occasioned only by the periodical thickening of the walls of the cells. Where not constricted the cells have the usual prismatic shape, with pores and septal striæ.

Formation and Locality.—The only specimen I have seen was collected by Mr. Murray, near Woodstock, C. W. It was found loose, but in lithological characters, it resembles the other species from the Corniferous limestone of that region.

MICHELINIA FAVOSOIDEA (Billings).

Description.—Corallum forming large hemispheric or flattened masses; cells unequal in size, adult diameter about two lines and a half; diaphragms, flat, horizontal, with small vesicular swellings, usually around the margins of the upper surface; septal striæ very obscure, six to eight on each plane side of the cells; pores, very small, irregularly distributed, sometimes in rows of five or six across the cell, about one-sixth of a line distant from each other in some places, and sometimes absent in spaces of half a line in width. This species has much of the aspect of *Favosites favosa,* Goldfuss, but is notwithstanding very clearly a true Michelinia.

Formation and Locality.—Corniferous. Rama's farm, Port Colborne.

Collector.—E. Billings.

Genus Zaphrentis (Rafinesque).

Generic Characters.—Corallum simple, elongated, free and turbinated, surrounded by a complete epitheca; cup more or less deep; no columella ?; a single fossette well developed and occupying the place of one of the radiating septa; these are in general well developed, denticulated upon their margins, and extend upon the surface of the transverse diaphragms to the central of the visceral chambers.

Edwards and Haime in the *Polypiers Fossiles*, page 326, have in substance given the above definition of this genus. In some of the species there is a rudimentary columella, and sometimes even in the same species the radiating septa may or may not reach the centre in different individuals.

Zaphrentis prolifica (Billings).

Description.—Corallum simple, turbinate, curved, with a few broad shallow encircling folds. Septal fossette of a pyriform shape, gradually enlarging from the margin towards but not quite reaching the centre, variable in its position in relation to the curvature of the fossil. Radiating septa in the adult specimens between sixty and seventy-five of the larger size, alternating with a like number of smaller ones, the former in some of the individuals extending to the centre on the bottom of the cup, where they are spirally twisted or irregularly contorted, in other specimens not reaching the centre, which is then occupied by a smooth space or often with a columella elongated in a direction from the septal fossette towards the opposite side. The septa are also sharp-edged for about half the distance from the bottom of the cup to the margin, then become gradually less projecting until at the edge of the cup they are reduced to mere flat rounded ridges. Length from four to five inches or a little more. Width of cup from two inches to two inches and a half. Depth of cup about one inch.

Very numerous specimens of young individuals of this species, one inch and a-half and upwards in length, and with fifty or more principal radiating septa occur along with those

full grown. These small ones might perhaps be regarded as constituting distinct species, but when good specimens can be observed they all exhibit the characters which are persistent in the large individuals.

The presence of the columella seems at first sight to be a sufficient ground for placing the individuals in which it occurs in the genus *Lophophyllum* (Edwards and Haime). I have however examined a great number of specimens and have found every gradation between the following characteristics.

1st. Specimens with a perfectly smooth space in the bottom of the cup, no columella.

2nd. With a columella slightly developed.

3rd. Columella large and prominent, with a smooth space all round.

4th. Columella well developed, but with a number of irregular often elongated tubercles in the surrounding smooth space.

5th. The septa reaching the columella, no smooth space.

6th. Septa covering the columella.

7th. Septa reaching the centre, with the columella either prominently, slightly or not all indicated beneath.

This last mentioned form must certainly be regarded as a true *Zaphrentis*, all other characters of the genus being present, and from it there is a regular series of forms leading in the seven directions above indicated or more. It appears to me therefore that so far from these specimens being divisible into several genera they only constitute one species.

The most persistent characters are the rounded edges of the septa near the margin of the cup, and the oval shape of the septal fossette, in the bottom of which where it reaches the side of the cup is a single septum which projects a little and partially divides the fossette.

This species somewhat resemble *Z. cornicula* (Lesueur), but differs in the edges of the septa, which are not dentated as in that species.

Formation and Locality. Devonian; Corniferous limestone. Extremely abundant at Rama's Farm near Port Colborne Canada West.

ZAPHRENTIS SPATIOSA (Billings).

Description.—Corallum short, turbinate, moderately curved and very broadly expanding. At the margin of the cup about ninety radiating septa alternately a little unequal and with their edges broadly rounded as in *Z. prolifica.* Length measured on the side of the greater curvature, about three inches, width of cup two inches and a-half. Septal fossette unknown.

This species is closely related to *Z. prolifica*, and may perhaps be united with it when its characters become more fully known.

Formation and Locality.—Devonian, Onondaga and Corniferous limestones, Rama's Farm, near Port Colborne Canada West.

Genus CYSTIPHYLLUM (Lonsdale.)

Generic Characters.—Corallum simple, turbinate, entirely filled with vesicular celluliferous structure; radiating septa, rudimentary or obsolete.

CYSTIPHYLLUM SULCATUM (Billings.)

Description.—Short, turbinate, much curved, expanding at the rate of between forty and forty-five degrees from the minute sharp curved point upwards; cup oblique, the lower margin being on the side of the lesser curvature, moderately deep and nearly regularly concave, the bottom covered with obscure coarse rounded radiating ridges; a shallow rounded groove or fossette extending from the centre to the higher margin, and in some specimens two others much less distinct radiating to the sides at right angles to the main groove. Exterior encircled by obscure undulations, and longitudinally striated by the rudimentary radiating septa. The vesicular structure consists of irregular sub-lenticular cells from half a line to two lines in width; length of the convex side from one inch and a half to three inches, the usual length appears to be about two inches or a little more; width of cup from one inch to one inch and a half; depth about half an inch.

This species when the interior cannot be seen might be mis-

taken upon a superficial examination for a small curved *Cyathophyllum* or *Zaphrentis*. It is about the size and shape of the curved specimens of *Petraia cornicula*.

Locality and Formation.—Rather common in the Corniferous or Onondaga limestone on Rama's farm, Port Colborne.

Collector—E. Billings.

Genus CYRTODONTA (Billings).

Generic Characters.—Equivalve, inequilateral; umbones near the anterior end; general form obliquely tumid, transversely sub-rhomboidal or ovate, posterior extremity larger than the anterior and usually broadly rounded; two muscular impressions, of which the posterior is superficial and the anterior sometimes deeply excavated; three oblique, often more or less curved, anterior teeth, situated either beneath or a little in front of the umbones; two or three remote posterior lateral teeth parallel with the hinge line; pallial line simple; ligament external; some of the species have a narrow area between or behind the beaks.

CYRTODONTA RUGOSA (Billings).

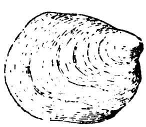


Fig. 1.

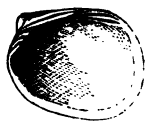


Fig. 2.

Figure 1. Exterior of right valve.
" 2. Interior of same specimen.

Description.—Small, sub-rhomboidal or sub-quadrate, the dorsal and ventral margins being somewhat parallel, and the anterior and posterior extremities obtusely rounded, the latter broader than the former; obliquely tumid from the beaks to the posterior ventral angle; the beaks rather small and incurved; a broad, shallow, scarcely perceptible depression extending from the ventral margin obliquely forward and upward towards the umbones; surface concentrically striated, and also marked with several more or less prominent sub-im-

bricating concentric ridges of growth; hinge line nearly straight, a little curved; interior shewing in the right valve three anterior teeth, the central one of which is the largest, and two posterior lateral teeth. In the left valve there appear to be four anterior teeth; but as the specimens are somewhat imperfect, this may not be the correct number. Width nine lines; length from the centre of the hinge line to the centre of the ventral margin, seven lines; depth of a single valve, three lines.

None of the specimens that I have seen are larger than the one represented in figures 1 and 2.

Locality and Formation.—Fourth Chute of the Bonne chère, Pauquette's Rapids, and at La Petite Chaudière Rapids near the city of Ottawa north side, associated with numerous fossils of the Trenton and Black River formations.

Collectors—Sir W. E. Logan, J. Richardson, E. Billings.

CYRTODONTA HURONENSIS (Billings).

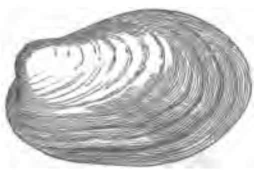


Fig. 3.

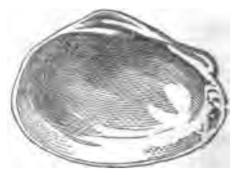


Fig. 4.

Figure 3. View of left valve from Lake Huron.
" 4. Interior of another specimen, same locality.

Description.—Transversely oval; anterior and posterior extremities rounded; ventral margin moderately convex, dorsal margin a little more convex than the ventral; umbones rather small, incurved; greatest tumidity extending from the umbones obliquely towards the posterior ventral angle; surface concentrically marked with fine striæ and ridges of growth. Width one inch five lines; length at the centre, one inch.

Locality and Formation.—The specimens are from an island in the group lying off Point Palladeau, Lake Huron, where they were found associated with Chazy, Black River and Trenton fossils; also at Point Claire, Island of Montreal.

Collector—A. Murray.

CYRTODONTA SUBCARINATA (Billings).

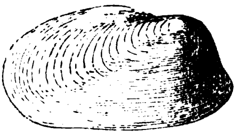


Fig. 5.

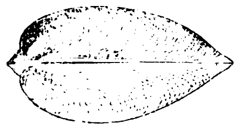


Fig. 6.

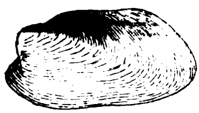


Fig. 7.

Figure 5. A specimen from Pointe Claire.
" 6. Dorsal view of same specimen.
" 7. A cast from lot 26, con. 5, Osnabruck.

Description.—Transversely sub-oval; ventral margin scarcely convex, straight or slightly sinuated for a small space of the centre ; dorsal margin elevated in the centre and sloping with a slight curve towards the posterior end, which is narrowly rounded, or truncate in the casts of the interior; umbones moderately small, incurved, and somewhat carinate for a greater or less distance; surface marked with obscure concentric ridges of growth. The interior has not been seen. Width one inch three lines; length nine lines.

This species may perhaps be considered a variety of the last; but the proportions are somewhat different, and it is always characterised by the strong, rounded carina, which extends from the umbones to the posterior ventral angle.

Locality and Formation.—Occurs at Pointe Claire and in numerous localities in the valley of the Ottawa in the top of the Chazy, throughout the Birdseye and Black River limestones, and in the base of the Trenton.

Collectors—Sir W. E. Logan, A. Murray, J. Richardson, E. Billings.

Cyrtodonta Canadensis (Billings).

Fig. 8.

Fig. 9.

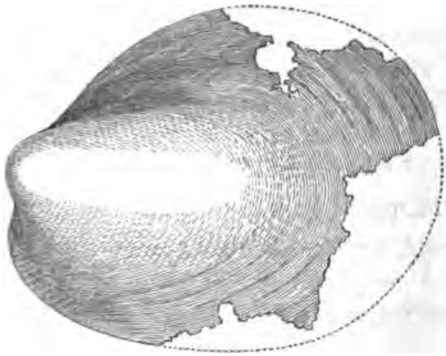


Fig. 10.

Figure 8. A small specimen from the north side of St. Joseph's Island, Lake Huron.
" 9. An elongated variety from the lower beds opposite the foot of the timber-slide, 4th Chute of the Bonne chère.
" 10. A large specimen from Pauquette's Rapids.

Description.—Transversely broad-oval; anterior, posterior, and ventral margins, and also the posterior half of the dorsal margin regularly rounded; a portion of the ventral margin about the centre of the width is sometimes nearly straight; dorsal margin elevated, somewhat compressed; diagonally and rounded ventricose from the umbones towards the posterior ventral angle; beaks short, obtusely rounded, incurved; surface nearly smooth or obscurely marked with concentric ridges; a few strong imbricating lamellæ of growth near the margin of some specimens. Width from fifteen lines to two inches and one-fourth; length from eleven lines to twenty-one lines.

Some of the specimens are a little more transverse than others; but there are intermediate forms connecting the specimen, represented by Figure 9, with Figures 8 and 10.

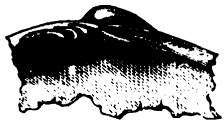


Fig. 11.

Fig. 11. A fragment, shewing the anterior teeth.

The anterior teeth are short, the central one being the longest and the most curved; the posterior teeth of the specimen represented by Fig. 10 are two in number, elongated and prominent.

Locality and Formation.—Island of St. Joseph's Lake Huron; La Petite Chaudière Rapids near the City of Ottawa; Fourth Chute of the Bonne chère and Pauquette's Rapids; associated with fossils of the Trenton and Black River formations.

Collectors—Sir W. E. Logan, J. Richardson, A. Murray, E. Billings.

CYRTODONTA SPINIFERA (Billings).

Fig. 12.

Description.—Small, sub-circular; greatest length and breadth about equal; moderately convex; hinge line much elevated; umbones small, incurved; dorsal margin nearly straight from the umbones about half-way to the posterior extremity of the hinge line; anterior, ventral, posterior and posterior half of dorsal margins broadly and regularly rounded; surface smooth, with a few short stout spines.

The specimen figured shews the anterior teeth: they are three in number, and do not differ from those of *C. rugosa* Length eight lines; breadth the same.

Locality and Formation.—Pauquettes Rapids, and Fourth Chute of Bonne chère, associated with fossils of the Trenton and Black River formations.

Collcctors—Sir W. E. Logan, J. Richardson, E. Billings.

CYRTODONTA OBTUSA (Hall sp.)

(*Ambonychia obtusa*, Hall, Palæontology of New York. Vol. 1, p. 167. Plate 36; Figures 8*a*, 8*b*.)

Fig. 13.

Fig. 14.

Figure 13. Left valve from Pauquette's Rapids.
" 14. Interior of some shewing the teeth.

Description.—The following is Professor Hall's description: "Obliquely ovate, short, gibbous; umbones short, obtuse, scarcely incurved or bending forwards; shell somewhat compressed towards the lower margin, convex on the centre and becoming inflated above; anterior side obtuse, rounded, scarcely extending beyond the umbones; posterior side compressed, scarcely alated; cardinal line straight, margin of shell curving from its posterior extremity; surface?"

"The specimens seen are casts, where the markings of the shell are not preserved. This species is distinguished from the others by its short, ovate form, as well as the shorter, very obtuse and gibbous umbones. It departs somewhat from the typical forms of the genus *(Ambonychia)*; but it has nevertheless the essential features, and cannot be referred to any other genus." (Pal. N. Y., vol. 1, page 167.)

Locality and Formation.—City of Ottawa, Belleville, and at Trenton on the Bay of Quinte, in the Trenton limestone; at the Fourth Chute of the Bonne chère, and also at Pauquette's Rapids very perfect specimens are common, associated with fossils of the Trenton and Black River formations.

Collectors.—Sir W. E. Logan, J. Richardson, and E. Billings.

CYRTODONTA SUB-TRUNCATA (Hall sp.).

Edmondia sub-truncata, Hall, Palæontology of New York, Vol. i., page 156, Plate 35, Figure 3 c, (not Fig. 9, Plate 34.)

This species is common in the Trenton and Black River limestones of Canada at all the localities above mentioned. The silicified specimens shew the internal characters of Cyrtodonta very clearly.

CYRTODONTA SUB-ANGULATA (Hall sp.).

Edmondia sub-angulata, Hall, Palæontology of New York, Vol. i., page 156, Plate 35, Figures 2 a, b.

A specimen of this species from Pauquette's Rapids exhibits in the right valve two posterior lateral teeth and an area between the beaks. That portion of the hinge line occupied by the anterior hinge teeth is destroyed, so that their character cannot be observed. There is an anterior muscular impression as in the other species.

It occurs at Pauquette's Rapids and at La Petite Chaudière.

CYRTODONTA CORDIFORMIS (Billings).

Description.—Sub-rhomboidal; cordiform; extremely ventricose; umbones strongly incurved; obtusely carinate on their upper side; the carination extending backwards and diagonally downwards, becoming more rounded and nearly obsolete before reaching the posterior ventral angle; the hinge-line is straight, short, and about at right angles to the direction of the carina; from the extremity of the hinge-line the posterior side slopes abruptly, but with a moderate curve, to the posterior ventral angle; ventral margin a little convex, and about as long as the posterior side; anterior margin half the length of the ventral, not much curved; anterior muscular scar oval and distinctly marked; surface concentrically striated. Length of largest specimen examined from the beaks to the posterior ventral angle, thirteen lines; length of hinge-line, seven lines; length of posterior and ventral sides, about ten lines each. The diagonal carina is not straight, but has a strong upward curve.

Locality and Formation.—East point of St. Joseph's Island, Lake Huron, Trenton Limestone.

Collector.—A. Murray.

CYRTODONTA SIGMOIDEA (Billings).

Description.—Sub-rhomboidal, ventricose, a strong obtusely angular carina extending from the closely appressed beaks with a sigmoid curve to the posterior ventral margin ; anterior end rounded, projecting a little in front of the beaks ; ventral margin longer than the dorsal and moderately convex ; posterior extremity obliquely truncate. Width one inch and a half; length from the umbones to the ventral margin thirteen lines.

Locality and Formation.—Hudson River group, Anticosti.

Collector.—J. Richardson.

Sub-genus VANUXEMIA (Billings).

Generic characters.—Ovate ; beaks terminal or sub-terminal ; posterior extremity rounded; anterior more or less acuminated ; two muscular impressions ; anterior teeth variable in number, sometimes curved and striated; posterior lateral teeth from two to four.

VANUXEMIA INCONSTANS (Billings).

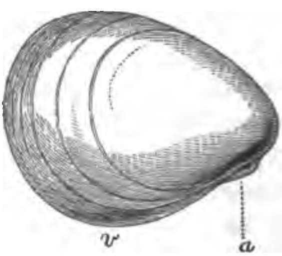


Fig. 15.

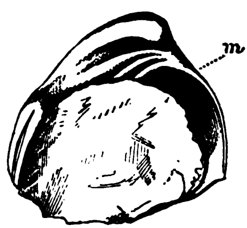


Fig. 16.

Figure 15. Right valve ; *v*, ventral margin ; *a*, the small anterior ear.
" 16. A fragment shewing the teeth obscurely ; *m*, the muscular impression.

Description.—Ovate ; moderately convex ; beaks terminal gradually expanding from the beaks to the posterior extremity,

which is broadly rounded; dorsal margin slightly and uniformly convex from the beaks to the posterior angle; anterior extremity represented by a very small projection beneath the beaks; ventral side regularly rounded, except a short space near the beaks, which is sometimes concave and partly occupied by the small projection of the anterior extremity. Three strong curving anterior teeth; two posterior lateral teeth; shell very thick towards the anterior end; a small area between the beaks; the anterior muscular impresssion is apparently excavated in the edge of the very thick shell. Surface with a few more or less strongly marked concentric furrows of growth. The beaks are short, rounded, and closely incurved.

The proportional length and breadth varies. The specimens are usually an inch and a half in length from the beaks to the posterior extremity, the greatest width from the dorsal to the ventral side being an inch and three or four lines. There is a small variety, scarcely an inch in length, and more obtuse at the anterior end, than the specimen figured; it is also more ventricose.

Locality and Formation.—Fourth Chute of the Bonne chère, La Petite Chaudière Rapids near the city of Ottawa, and numerous localities in the valley of the Ottawa, associated with fossils of the Black River and Trenton formations.

Collectors.—Sir W. E. Logan, E. Billings, J. Richardson.

VANUXEMIA BAYFIELDII (Billings).

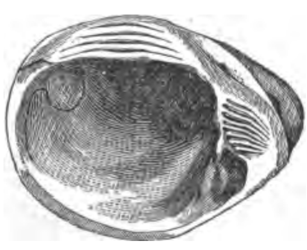


Fig. 17.

Figure 17. Interior of the left valve of *V. Bayfieldii.*

Description.—Very ventricose; ovate; the anterior extremity, including the beaks, narrowly rounded; the posterior end

broadly rounded; shell very thick; seven anterior teeth; four posterior teeth; anterior muscular impression large, deep, and excavated in the very much thickened edge of the shell; posterior muscular impression sub-circular, superficial and situated just beneath the posterior extremity of the hinge line.

The specimen figured is deeply imbedded in a coral (*Monticulipora petropolitana*), and only exhibits the edges and inside of the shell. From the great thickness of the shell, casts of the interior must bear very little resemblance to a perfect specimen. The form is very like that of *Vanuxemia inconstans*, but the characters of the interior leave no doubt as to its distinctness.

Locality and Formation.—Bayfield Sound, Lake Huron a single loose specimen; Lower Silurian appears to be of the Hudson River Group.

Collector.—A. Murray.

Genus MATHERIA (Billings.)

Generic Characters.—Transverse; equivalve; inequilateral; beaks near the anterior end; dorsal and ventral margins sub-parallel; two small obtuse cardinal teeth in the left valve, and one in the right; no lateral teeth; two muscular impressions; ligament external.

This genus is dedicated to Mather, one of the Geologists of the New York Survey.

MATHERIA TENER.

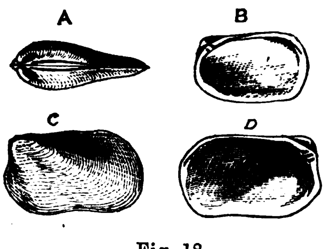


Fig. 18.

Figure 18. A, dorsal view of *Matheria tener*; B, interior of right valve; C, exterior of left valve; D, interior of left valve.

Description.—Small, oblong, depressed; dorsal and ventral margins nearly straight and parallel; upper half of posterior extremity obliquely truncate; lower half rounded; anterior extremity sub-truncate from the beaks nearly to the anterior ventral angle, which is rounded, and projects slightly beyond the umbones. From the beaks to the anterior ventral angle extends a prominent obtusely angular canina; surface marked with fine concentric striæ. Width eight lines; length four lines.

Locality and Formation.—Blue Point, Lake St. Johns; Trenton limestone.

Collectors—J. Richardson, R. Bell.

Genus OBOLUS (Eichwald.)

OBOLUS CANADENSIS (Billings.)

Fig. 19.

Fig. 20.

Fig. 21.

Fig. 22.

Fig. 23.

Figure 19. Dorsal valve.
20. Interior of dorsal valve.
21. Dorsal view of an elongated specimen which has both valves in place but a little distorted.
22. Side view of the same specimen.
23. Ventral view.

Description.—The form of this magnificent species is somewhat variable, the width being often greater than the length, and sometimes less. Usually, it is transversely broad-oval; the apex of the dorsal valve obtusely angular, and that of the ventral rather acute. The dorsal valve is moderately and pretty uniformly convex; the ventral valve depressed-convex. The beak of the ventral valve projects about two lines above that of the dorsal valve, and exhibits a wide, scarcely concave area, with a triangular excavation representing the obsolete foramen; the surface is smooth, or with a few concentric imbricating furrows of growth. In the inside of the dorsal valve there are near, but above the centre, two pyriform muscular impressions, with their pointed extremities close together and directed downwards, while in the upward direction they diverge outwards; they are separated by an obscure rounded ridge, and surrounded on the lower side by an elevated angular border, which forms a projecting point just below their lower extremities. Beneath and close to the hinge there is a narrow and deep flexuous furrow. The muscular impression at the cardinal angles figured by Davidson in *O. Apollinis* (Eichwald), *O. transversa* (Salter), and *O. Davidsoni* (Salter), are very indistinct in this species; the area of the ventral valve does not appear to be striated. The interior of the ventral valve is not clearly shewn in any of our specimens. Width usually about two inches, but some of the fragments undoubtedly belonged to individuals which were three inches wide. The length from the beaks to the base, is either equal to or a little greater or less than the width, the dimensions being variable.

Locality and Formation.—Occurs abundantly at the Fourth Chute of the Bonne chère, Pauquette's Rapids, and in the Townships of Stafford and Westmeath, County of Renfrew, associated with fossils of the Trenton and Black River limestones.

Collectors—Sir W. E. Logan, J. Richardson, and E. Billings

Genus EICHWALDIA (Billings.)

Generic Characters.—Large valve perforated on the umbo for the passage of the peduncle; the place of the foramen

beneath the beak occupied by an imperforate concave plate, the interior divided by an obscure medio-longitudinal ridge; interior of smaller valve divided throughout from the beak to the front by a very prominent medio-longitudinal ridge; no hinge, teeth, sockets, or other articulating apparatus in either valve.

After a great deal of examination and comparison I have not been able to refer the species for which the above generic name is proposed to any of the described genera. Although several silicified specimens exhibiting the interior have been obtained, they do not show any muscular impressions. The perforation on the back of the beak was at first supposed to be a fracture, but we have now specimens which exhibit its characters so completely that I do not think it possible there can be any mistake. The internal structure of the larger valve somewhat resembles that of *Pentamerus* or *Camarophoria*, the concave plate beneath the beak appearing to be the homologue of the floor of the triangular chamber found in these genera. I cannot make out however, that it is in any way connected with the medio-longitudinal ridge as is the case in both *Pentamerus* and *Camarophoria*. In removing the limestone from silicified specimens the delicate processes in the interior of species of brachiopoda are very often destroyed, and it is possible that the connection in question may exist in perfect specimens, but not appear after treatment with acids. It is therefore uncertain whether or not it is attached to the plate beneath the beak. If it should be hereafter ascertained that it is so connected, the foramen on the umbo would still be sufficient to show that this is a new genus, to the establishment of which the characters of the smaller valve and the absence of any articulating and apophysary apparatus would be additional characters. As other specimens can be procured and as the internal characters cannot be well shewn by wood-engraving, I shall for the present give figures of the exterior only.

EICHWALDIA SUBTRIGONALIS (Billings.)

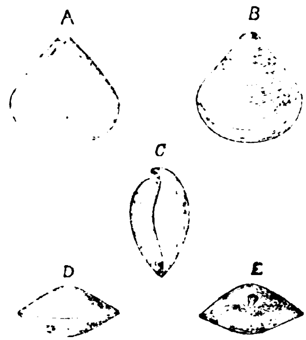


Fig. 24.

Figure 24. A, dorsal view ; B, ventral ; C, side ; D, front ; E, apex, shewing the foramen.

Description.—Sub-triangular ; both valves moderately convex and smooth, apical angle about ninety degrees or a little less ; sides from the beak to about one half the length straight, then rounded ; front more or less broadly rounded ; beak of larger valve extended, incurved at the point and with a moderately large concave area ; beneath beak of smaller valve strongly incurved apparently entering the visceral cavity beneath the area of the larger valve ; length and width about equal.

Locality and Formation.—Fourth Chute of the Bonne-chère and Pauquette's Rapids, associated with numerous fossils of the Black River and Trenton Formations.

Collectors—Sir W. E. Logan, J. Richardson, E. Billings.

I have the honour to be,

Sir,

Your most obedient servant,

E. BILLINGS.

REPORT

FOR THE YEAR 1857,

OF

T. STERRY HUNT, Esq.,

CHEMIST AND MINERALOGIST TO THE GEOLOGICAL SURVEY OF CANADA,

ADDRESSED TO

SIR W. E. LOGAN, F.R.S.,

DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

MONTREAL, 1st *March*, 1858.

SIR,

I have now the honour to lay before you some of the results of my chemical investigations in connection with the Geological Survey during the past year. In the first place, and in continuation of the inquiries suggested in my last report, I have to offer a series of analysis of various dolomites and magnesian limestones, and to give the results of some experiments which serve to explain the conditions and mode of their formation. In this connection it may be well to recall some of the principal facts in the history of dolomites, as a preliminary to the researches and discussions which are to follow.

DOLOMITES.

The name of dolomite, as is well known, is employed to designate a mineral which in its purest state is composed of equivalent weights of carbonate of lime and carbonate of magnesia, these being in the proportions of 50 to 42, or in 100 parts of 54·35 of carbonate of lime, and 45·65 of carbonate of magnesia. This compound is distinguished from carbonate of lime by its greater density (which is from 2·85 to 2·90), and by its somewhat superior hardness. It is also much less readily attached by acids than carbonate of lime, and at ordinary temperatures does not perceptibly effervesce with nitric or muriatic acids, unless reduced to powder. When calcined it gives a mixture of lime and magnesia, which is said to yield a stronger mortar than ordinary lime, but which slakes slowly and with but little evolution of heat.

A portion of the magnesia in dolomite is often replaced by protoxyd of iron, and more rarely by oxyd of manganese. The dolomites containing carbonate of iron are generally yellowish or reddish on their weathered surfaces, from the change of a portion of the iron into hydrated peroxyd, and those containing carbonate of manganese become brownish-black on the exterior from a similar cause. Both of these cases may be observed in the dolomites of the Eastern Townships of Canada.

Besides the crystallized dolomites which occur in veins and cavities in various rocks, and have received the names of *bitter-spar* and *pearl-spar*, (the latter in allusion to the pearly lustre of the faces of the rhombohedron, which are generally curved), we find this double carbonate forming great beds of a rock which is also known by the name of magnesian limestone. The yellow magnesian limestones of the Permian system in England are those best known, and have in some cases a total thickness of 300 feet. They are immediately overlaid by gypseous marls, to which succeed the limestones, gypsum and rock-salt of the Triassic series. Similar magnesian limestones occur in the Devonian and Carboniferous formations of England and Russia. Descending in the geological series, we find in the Saliferous group of Western Canada and New York, beds

of dolomite with gypsum, (see Report for 1856, p. 475); and immediately below, in the Niagara group, there occurs a remarkable deposit of dolomite about to be described. In the Report just cited, p. 465, I have described the dolomites which occur interstratified with pure limestones in the Hudson River group. The examinations of Messrs. Owen and Whitney have shown that in Michigan, Iowa, and Minnesota, the calcareous strata immediately overlying the Potsdam sandstone, and corresponding to the Calciferous sand-rock, are highly magnesian, often constituting true dolomites; and I have found thin layers of dolomite among the limestones of the Chazy division on the island of Montreal. The argillaceous limestone from this formation at Hull, which is employed as a hydraulic cement, also contains about 20 per cent. of magnesian carbonate.

Beneath the oldest known fossiliferous rocks, and among the limestones of the Laurentian series, we meet with great beds of dolomite, sometimes ferriferous, and often containing serpentine and other silicious minerals (see Report already cited, pp. 366 and 482.)

When on the other hand, we ascend from the Permian, we find the Jurassic formation of the Alps containing immense masses of dolomite, which also occur in the same formation in France and Germany. In the Cretaceous formation dolomites occur in Gascony, and in the Paris basin; and in 1855 I visited in company with the members of the Geological Society of France, a deposit of dolomite in the Tertiary strata at Pont St. Maxence, in the valley of the Oise, in France, since described in the Bulletin of the Society. The dolomite, which there reposes upon the nummulitic limestone, and is overlaid by the *calcaire grossier*, forms irregular beds or masses several feet in thickness. It is in the form of an incoherent sand, which consists according to Damour, of nearly pure crystalline dolomite, with a little bitumen and some quartzose sand. Between it and the overlying fossiliferous limestone, is a thin layer of yellowish tufaceous cellular limestone, which does not contain a trace of magnesia. (See Bulletin of the Geol. Soc. of France, vol. xiii., p. 67.)

We are indebted to Mr. J. D. Dana for the discovery of a

dolomite of recent origin in Matea, an elevated coral island near Tahiti, where among the limestones which he supposes to be formed by the solidification of coral mud, is one containing 8.3 per cent. of carbonate of magnesia, and another which according to Prof. Silliman, jr., yields 38.07 per cent. of carbonate of magnesia. This dolomite, which is compact, finely granular and very tenacious, is at the same time cavernous, and I found its density in powder to be 2.83, its hardness being above 4.0. Analysis gave me 38.25 per cent. of carbonate of magnesia, 0.30 of silica, and 60.50 of carbonate of lime.—(*Am. Jour. of Science*, [2] xiv. p. 82, and xix. p. 429.)

The preceding dolomites belong to marine formations, but dolomites are said to occur in the lacustrine limestone at Dächingen near Ulm, and in the brown-coal formation at Giessen.

It appears then from the facts which we have here cited, that the production of dolomites was continued from the time of the earliest known stratified rocks up to the tertiary period, and is perhaps even now going on.

Physical Characters of Dolomites.—Apart from the altered crystalline dolomites of metamorphic strata, the generally crystalline texture of those of unaltered regions is remarkable. In some cases the rock is an aggregate of pearly, cleavable grains of dolomite, which occasionally have but little coherence, or are in the form of loose sand. At other times the rock is concretionary, having an oolitic or a botryoidal structure, the masses often exhibiting a radiated arrangement; more rarely compact varieties of dolomite are met with. The concretionary action has sometimes, according to Lyell, so far disturbed the original arrangement as to obliterate the marks of stratification. Most dolomites exhibit cavities, which have often been filled by subsequent deposits of other minerals, and seem to indicate a contraction, apparently attendant upon chemical change after the deposition of the rock.

A remarkable mode of occurrence is that in which dolomite forms the cement of breccias and conglomerates. I have in my last report described rocks of this kind from the Quebec division of the Hudson River group, where rounded fragments of limestone, shale, and even of dolomite, have been re-cement-

ed into a rock by the introduction of a crystalline ferriferous dolomite. Analogous to this is the well-known conglomerate of the Permian system near Bristol, and in other parts of England, where in hollows of the Mountain Limestone, are found accumulations of fragments of this limestone, with others of coal-shale, mixed with bones and teeth of saurians; the whole cemented together by a red or yellow dolomite, and resting unconformably upon the Carboniferous strata. Similar conglomerates occur in the same formation in Normandy, where they enclose concretionary masses of nearly pure dolomite, while in the Permian rocks of the Vosges concretions of sandy dolomite occur imbedded in layers of micaceous sandy clay, itself sometimes agglutinated by a dolomitic cement. (*Explication de la Carte Géologique de France*, ii., pp. 15 and 128.)

In this connection I must recall the existence of a crystalline ferriferous dolomite filling the shells of *Orthoceras*, *Pleurotomaria* and *Murchisonia*, as also small fissures in the non-magnesian Trenton limestones of Ottawa, described in the Report for 1852, p. 174; and I have to remark the existence of similarly replaced fossils in the Chazy limestone at Montreal. But while these dolomitic casts occur in pure limestone, I have presently to describe beds from the Niagara formation, in which, on the contrary, purely calcareous corals occur imbedded in a yellow magnesian limestone.

Having thus brought together the principal facts in the history of magnesian limestones, I proceed to give the analytical results in support of several of these points, at the same time referring to previous Reports already cited for other analysis :—

Dolomites of the Laurentian series: 1846, p. 124; 1853–56, pp. 366—482.
Dolomites of the Silurian series: 1852, p. 174; 1853–56, p. 465.

Analyses of Limestones and Dolomites.

Chazy Limestone.—Between the beds of the dark compact fossiliferous limestone at the quarries near the St. Lawrence toll-gate, Montreal, there are found irregular interrupted layers, occasionally an inch or more in thickness, of a yellow pulverulent

material, containing great numbers of fragments of encrinal stems. The matrix is easily crushed, permitting us to separate the organic remains by means of a seive. A portion of the yellow powder thus obtained was dissolved with effervescence by hydrochloric acid, leaving only a residue of white silicious matter, and the solution contained lime, magnesia and iron, but no alumina ; nor could the presence of manganese, nickel, or any allied metals, be detected. The analysis, which represents a very ferriferous dolomite with an excess of iron, gives the iron as carbonate, while it exists in part as peroxyd, and hence the slight increase. 100 parts gave me :—

Carbonate of lime,	40·95
" of magnesia,	24·19
" of iron,	27·03
Insoluble sand,	9·01
	101·18

A portion of grayish crystalline limestone, distant about an inch from the magnesian layer, left on solution in acid, 18·4 per cent. of white insoluble matter, and gave only 1.09 per cent. of carbonate of magnesia, the rest being carbonate of lime.

At the above locality there are found casts of orthoceratites, consisting of a coarsely lamellar white dolomite, weathering reddish-yellow, crumbling, and evidently very ferruginous. These are imbedded in a nearly black, fine-grained limestone, which, as in the case of similar specimens from Ottawa, is traversed by thin, irregular veins of dolomite, leading to the casts. A portion of this black limestone was dissolved in hydrochloric acid, during which process the carbonic acid gas evolved contained traces of sulphuretted hydrogen. A little iron pyrites remained in the insoluble residue, and was dissolved by nitric acid with separation of sulphur. The residue thus purified, was black when dry from the presence of carbonaceous matter, but became white by ignition in the air, and then equalled 12·8 per cent. of the rock. A dilute solution of soda, aided by heat, removed from the calcined residue 9·47 per cent. of silica, leaving a matter having nearly the composition of a feldspar. It was examined for sulphate of baryta, which I once

detected in the insoluble residue of an earthy limestone, but contained only a trace of sulphuric acid. An analysis by fusion with an alkaline carbonate, gave me :—

Silica,	73·02
Alumina,	18·31
Lime,	·93
Magnesia,	·87
Alkalies, by difference,	6·87
	100·00

Dolomite of Dudswell.—In your Report for 1847, p. 54, you have described the Upper Silurian limestones of Dudswell, which are often more or less micaceous and interstratified with micaceous schists, but contain, in a state which admits of their identification, the characteristic fossils of the Niagara group. Sometimes the rock consists of masses of corals of the genera *Cyathophyllum*, *Porites* and *Favosites*, imbedded in a yellowish granular paste. The dark, almost black colour of the polished corals, which generally exhibit organic structure, contrasts agreeably with the yellow base. In other portions the structure of the rock seems to be due to the fact that beds of gray fossiliferous limestone have been broken and shattered, generally in the plane of stratification, and the fissures subsequently filled up with the yellow paste, which forms layers, sometimes half an inch thick, occasionally enclosing the fragments of gray limestone. Blocks of this variety which you have caused to be cut and polished, yield a marble of considerable beauty.

A chemical examination of these rocks shows that while the fossils, and the grayish base which often envelops them, are pure carbonate of lime, the yellowish portions are magnesian. A fragment of the gray, finely granular limestone, gave me 6·2 per cent. of insoluble sand, a trace of oxyd of iron, and 1·3 per cent of carbonate of magnesia, the rest being carbonate of lime.

A specimen of the yellow portion freed from iron pyrites, which is often disseminated through it in crystals, gave me as follows :—

Carbonate of lime,	56·60
" of magnesia,	11·76
" of iron,	3·23
Insoluble quartz sand,	26·72
	98·31

The proportion of magnesia here present is far from being sufficient to form with the lime a dolomite. Karsten, however, many years since pointed out that acetic acid in the cold scarcely attacks dolomite, although readily dissolving carbonate of lime; so that magnesian limestones, when treated with this acid, leave a residue of dolomite. By taking advantage of this reaction, I found a lamellar crystalline limestone from Loughborough, which contains 7·5 per cent. of carbonate of magnesia, to be a mixture of dolomite and carbonate of lime, (Report 1853–6, p. 366), and the same mode of analysis was now applied to the yellow magnesian limestone of Dudswell. When reduced to powder it effervesced freely with acetic acid in the cold, and when a renewed application of the acid no longer produced effervescence, the residue was carefully washed and dried. A weighed portion of it was then digested with dilute hydrochloric acid, which left a residue of 52·0 per cent. of sand and pyrites. The composition of the soluble part was as follows:—

Carbonate of lime,	51·75
" of magnesia,	35·73
" of iron,	12·52
	100·00

The above numbers correspond very exactly to a dolomite, in which a portion of magnesia is replaced by protoxyd of iron, while the portion dissolved by acetic acid contained 4·0 per cent. of carbonate of magnesia, and only a trace of iron. The pyrites of this magnesian limestone contained no traces of cobalt or nickel.

Portor Marble.—The resemblances as to color and structure, between the marble of Dudswell and the black and yellow marble from northern Italy, known by the name of *Portor*,

were such, that I was induced to examine the latter. This marble is chiefly wrought in the Gulf of Spezzia, and according to Savi, belongs to the Neocomian formation. It has a black or dark-gray ground, susceptible of a high polish, and is penetrated by irregular veins of a deep yellow or reddish-brown color. These seem to envelope the black masses, and sometimes to give rise to a breccia.

A well characterized specimen of Italian portor was chosen for examination. The black compact portions dissolved in hydrochloric acid, leaving no appreciable residue, and contained 1·0 per cent. of carbonate of magnesia, the rest being carbonate of lime. The yellow veins were granular in their texture, closely resembling those of the Dudswell marble. By solution in hydrochloric acid, they left a residue of silicious sand equal to 4·6 per cent., and the solution gave besides lime and a little oxyd of iron, magnesia equal to 35·5 per cent. of magnesian carbonate.

Dolomitic Conglomerate of St. Helen.—In your Report for 1857, p. 15, you have described as occurring on the Island of St. Helen, a peculiar conglomerate rock, made up of pebbles of shale, chert, sandstone, and sometimes of limestone, which latter contain organic remains of Lower Silurian age, the whole cemented by a calcareo-silicious paste into a mass exceedingly tough, and so solid, that a fracture from a blow passes equally through the pebbles and the matrix. The rock is grayish within, and weathers deeply of an ochre-yellow. In the report already cited, you expressed a doubt as to the age of this conglomerate, which at St. Helen reposes upon the Utica slate, but you have since recognized it as belonging to the Lower Helderberg series of the New York geologists.

Acids at the ordinary temperature, have but little effect on this rock; but by the aid of heat, dissolve from it a large amount of carbonates with effervescence. A portion of the fine-grained paste gave to hydrochloric acid 46·0 per cent. of soluble matters, consisting of lime, magnesia and protoxyd of iron, with but a trace of alumina, and left a silicious sand. The composition of the soluble part was as follows :—

Carbonate of lime,	....	57·8
" of magnesia,	....	16·4
" of iron,	....	25·8
		100·00

You subsequently found a similar yellow-weathering conglomerate reposing on the Calciferous sand-rock at Isle Bizard; and Mr. Richardson has observed it in a like position at Ste. Anne; also resting upon Laurentian rocks at Mont Calvaire; and at the White-Horse Rapids upon the Trenton limestone. I have examined specimens of the conglomerate from the last three localities, and have in each case found the cement to be a magnesian carbonate of lime, with a large amount of carbonate of iron. These conglomerates however offer some varieties in their colour and their imbedded minerals. That from Ste. Anne has a base somewhat greenish in color, while that from Mont Calvaire is bluish, and holds in addition to pebbles of chert and sandstone, fragments of orthoclase, and others of the violet-coloured triclinic feldspars of the Laurentian rocks. It also contains in abundance, masses of cleavable black augite, and others of brownish-black mica. The conglomerate of the White-Horse Rapids has a dark greenish base, apparently more homogenous than the preceding, and contains in addition to quartzite, augite and mica, small fragments of a mineral resembling obsidian. Large blocks of a similar conglomerate, with a greenish, reddish-weathering dolomitic base, are found along the shores of the Island of Montreal, near Lachine. In some of these blocks, rounded masses of black cleavable augite an inch or two in diameter are met with, besides large plates of mica, and more rarely fragments of dark green olivine, half an inch in diameter.

The cement of these conglomerates is not however always dolomitic, for some of the beds at Mont Calvaire are distinguished by the absence of any yellow colour on the weathered surfaces, and by effervescing freely with acids. The cement of these is a nearly pure carbonate of lime, without iron and with but a trace of magnesia.

Point Lévis.—In my last report, (p. 464) I have described the conglomerates of Point Lévis, which in a paste of silicious yellow-weathering dolomite, hold pebbles of pure limestone, and others of yellow crystalline dolomite. One of the latter yielded on solution 4·6 per cent. of silicious sand, and the solution, besides carbonate of lime and a little iron, gave 33·8 per cent. of magnesia. These imbedded masses of dolomite are perhaps concretionary.

A fragment of the travertine whose beds occur associated with these dolomites, gave me by analysis, 9·3 per cent. of silicious sand, and 0·75 per cent. of carbonate of magnesia, the remainder being pure carbonate of lime. Prof. J. W. Dawson, who has kindly examined a section of this limestone microscopally, finds in it no trace of organic structure, and confirms my opinion, expressed in my last report, that it is a travertine or calcareous sinter.

Gaspé.—The lower portion of the Hudson River group in Gaspé, exhibits in several parts a thin-bedded, black, very compact rock, of an argillaceous aspect, associated with graptolitic shales. It weathers reddish-yellow, and is characterized by the occurrence of thin crystalline crusts of carbonate of lime adhering to the surface of the beds, and giving to portions an appearance like what is called *moiré*. The rock is but slightly attacked by acids in the cold; hydrochloric acid decomposes it however by heat, leaving a residue of fine white argillaceous matter. The analysis gave as follows:

Carbonate of lime,	43·17
" of magnesia,	32·12
Oxyd of iron with alumina,	4·10
Insoluble residue,	20·30
	100·00

From the proportion of argillaceous matter which this dolomite contains, it was probable that it might yield a hydraulic cement. By calcination it assumed a pale buff colour, and when afterwards pulverized and made into a paste with water, became hard after five minutes under water, and soon acquired

a great degree of solidity. It will probably prove to be very valuable for hydraulic constructions.

Manganesian Dolomite.—The dolomites of the Eastern Townships have been described in previous reports as often associated with chrome, titanium and manganese. The iron ore of the 9th lot of the 9th range of Sutton occurs in part as a band of massive peroxyd, and in part as octahedral crystals of magnetite, disseminated with chlorite through a grayish granular dolomite, which weathers brownish-black from the presence of manganese. The crystals of iron ore are arranged in bands in this dolomitic belt, portions of which, an inch or two in thickness, are often free from imbedded minerals. Such a portion was taken for analysis and gave the following results:—

Carbonate of lime,	40·10
" of magnesia,	20·20
" of iron,	10·65
" of manganese,	7·65
Insoluble,	21·45
	100·00

The insoluble residue was nearly pure quartz. The associated crystals of magnetite contained no foreign metals. The dolomite, which contained no trace of nickel or cobalt, is remarkable for the large amount of carbonate of manganese, whose occurrence is interesting in connection with the presence of this metal in two distant parts of the same series of rocks. In the metamorphic strata of Massachusetts, New Hampshire and Maine, beds of manganese spar occur interstratified with micaceous schists. This spar is not a pure silicate of manganese, but contains small portions of lime and iron as silicates, together with grains of quartz, and in some cases considerable amounts of disseminated carbonates of manganese, iron and lime.

In the Island of Newfoundland, a massive carbonate of manganese has been found at Placentia Bay, imbedded in slates which are supposed to be of Silurian age. This mineral, for a specimen of which I am indebted to Prof. Dawson, is compact and impalpable in texture, brittle, with a conchoidal

fracture and a feeble waxy lustre ; slightly translucent on the edges; colour, fawn to pale chesnut-brown; streak white; hardness 4·0; density, 3·25. The specimen shows faint lines, which seem to be those of deposition, and give to the mass the aspect of a sinter. It is incrusted and penetrated in parts with black crystalline oxyd of manganese.

This mineral is not attacked by acids in the cold, but with heat readily dissolves in nitric acid with effervescence of carbonic acid, leaving a residue of 14·4 per cent. of silica, of which all but two per cent. were readily soluble in a dilute solution of potash. It contained besides, 84·6 per cent. of carbonate of manganese, with small portions of lime and iron, and a trace of magnesia. This substance is thus, apart from the intermingled silica, a very pure carbonate of manganese or diallogite. Manganese, from the facility with which it passes into a higher state of oxydation, is generally separated in the form of peroxyd from those mineral waters which contain it, although Sir Robert Kane has described a deposit of an impure earthy variety of carbonate of manganese from beneath a bog in Glendree, in Ireland. The occurrence of this carbonate mixed with silica in Silurian rocks, enables us to explain the formation of the beds of silicate of manganese which occur in the metamorphic strata of the same age.

Dolomites of Galt.—The magnesian character of large portions of the Niagara limestone in the Western United States, has been noticed by Mr. Whitney, in his Report on Lake Superior and the adjacent regions. The geodes of pearl-spar from Niagara Falls, which are associated with calcite, selenite, and more rarely with the sulphates of baryta and strontia, and with fluor-spar, occur (at least in the specimens now before me,) in a finely granular magnesian limestone. In the vicinity of Galt, we meet with a remarkable formation of dolomite, which is interposed between the Niagara limestone and the overlying Onondaga salt group, and attains, even in Western Canada, a considerable, but as yet undetermined thickness. It corresponds, according to Mr. James Hall, to the magnesian limestone of Leclaire, on the Mississippi river, which has there a thickness of 500 feet. It is characterized at Galt by the presence, in great numbers, of the casts of the interior of *Me-*

galamus Canadensis, the shells of which have disappeared. The casts, as well as the enveloping rock, are made up of a yellowish-gray crystalline dolomite. The vacant spaces left by the disappearance of the shell retain its markings, and have small crystals of dolomite scattered over their walls.

Besides the rock from Galt, I have examined four other specimens of this magnesian limestone from that vicinity, which are wrought as building stones, and which you placed in my hands. The first of these is from McDonald's quarry, Guelph; the second from Howitt's quarry, Puslinch; and the third and fourth from Strange's quarry, Rockwood. The first three closely resemble each other and the dolomite of Galt. They are made up of crystalline cleavable grains, which under a lens, exhibit the pearly lustre characteristic of dolomite. The rock is of a yellowish colour, cellular, exhibiting little cavities lined with crystals, and is not very strongly coherent, The first three specimens exhibited no fossils; but the fourth specimen, which is more coarsely crystalline, and more coherent than the others, contains in great numbers, fragments of encrinal columns, replaced by a white spar, whose colour contrasts with the bluish tint of the base. This rock is cellular like the last, and is in every part a dolomite. These specimens effervesce very feebly with cold acids, but are dissolved by the aid of heat, leaving in the case of three and four, 0·90, and 0·65 per cent. of insoluble matter. They are all pure dolomites, containing 54·0 per cent. of carbonate of lime, the rest being carbonate of magnesia.*

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* The following facts with regard to the dolomites of the palæozoic rocks of the Mississippi valley have been kindly furnished me by Mr. James Hall. We have in ascending order—

1. The so-called Lower Magnesian limestone, which is the equivalent of the Calciferous sandrock, and is from 200 to 250 feet thick. It is the lead-bearing rock of Missouri, and probably contains the cobalt ores of that region.

2. The Galena limestone; about 250 feet of dolomite interposed between the Trenton and the Hudson River group. It is the lead-bearing rock of Iowa, Wisconsin and Illinois.

3. The Niagara limestone, also dolomitic, about 250 feet thick, and sometimes holding galena and blende.

4. The Leclaire or Galt dolomite already described.

5. The magnesian limestone of the Onondaga salt group—100 feet thick.

6. A dolomitic deposit in the upper part of the Carboniferous limestone series.

Dolomites with an excess of Magnesia.—We have seen that pure dolomites consist of equal equivalents of the two carbonates, corresponding to 54·35 of carbonate of lime and 45·65 of carbonate of magnesia, and that where the carbonate of lime is in excess, it is in a state of mixture, and readily removed by acetic acid from the double carbonate. There are not wanting, however, rocks in which the magnesian carbonate predominates over the lime, leading us to suppose a mixture of magnesite with the dolomite.

The examples of dolomites with an excess of carbonate of magnesia are numerous. Of two specimens from the Muschelkalk of Thuringia, one gave to Rammelsberg, 51·54 of carbonate of lime and 48·57 of carbonate of magnesia; while the other yielded to Senft, 42·9 of carbonate of lime and 55·4 of carbonate of magnesia, besides 2·7 of carbonate of iron =101·1. (Senft, *die Felsarten*, p. 130.) A very pure bituminous dolomite from the Salzberger Alps, gave to Lippold, carbonate of lime, 51·48; carbonate of magnesia, 46·13; and a lacustrine dolomite from the brown-coal deposit near Giessen, afforded Knapp, carbonate of lime, 42·80; carbonate of magnesia, 49·63; oxyd of iron, 1·65; insoluble, 1·42.* In like manner, Whitney (Report on Lake Superior, vol. ii. p. 193,) found for a dolomite from the Calciferous sand-rock, carbonate of lime, 25·28; carbonate of magnesia, 32·57; besides 0·45 of oxyd of iron, traces of alumina, and 37·0 of sand. A direct determination of the carbonic acid confirmed the correctness of this analysis.

The variegated marls of the *keuper*, or upper part of the Triassic system in Germany, according to Alberti, often contain an excess of magnesian carbonate, and are very slightly attacked by acids. The analysis of a tender greenish-gray schistose marl from Tubingen, gave carbonate of lime, 14·56; carbonate of magnesia, 19·10; oxyd of iron, 3·40; alumina, 3·92; clay, 59·12=100·10. (Senft, *die Felsarten*, p. 134.)

A dark-gray rock associated with limestone from the *keuper* near Solothurn gave to Völckel: carbonate of iron, 33·94; carbonate of magnesia, 54·55; carbonate of lime, 0·67; silicate

* See Liebig and Kopp's Jahresbericht, 1848, vol. ii. page 501, (Eng. ed.)—and 1851, p. 873.

of alumina, 8·89; water and organic matters, 1·95.—(L. & K., *Jahresbericht*, 1849, p. 581. Eng. ed.)

In these two analyses we see the transition from dolomites to a ferriferous magnesite like those of Sutton and Bolton, described in my Report for 1856, p. 460.

ON THE ORIGIN AND FORMATION OF DOLOMITES AND MAGNESIAN LIMESTONES.

This question has long been regarded as one of extreme difficulty, and among the many solutions hitherto proposed none appear to be satisfactory. I propose to notice them briefly, and to indicate the facts and experiments which bear upon the subject.

Agency of Organic Life.—In a previous Report I have alluded to the well-known fact that carbonate of magnesia occurs in but very small quantities in calcareous tufas and travertint. The same thing is true in the case of limestones of organic origin, which are generally nearly pure carbonate of lime. The limestones of Montreal and Dudswell among others, seldom contain more than one per cent. of carbonate of magnesia. Such limestones are made for the greater part of the remains, often finely comminuted, of corals and mollusks, and the living species of these are in general nearly pure carbonate of lime. The analyses of Silliman and myself, and the more recent ones of Forchammer, show that corals generally contain less than one per cent. of magnesian carbonate; and the same is true of the shells of *Nautilus*, *Pinna*, *Tritonium*, *Cerithium*, *Terebratula* and *Modiolopsis*. Forchammer however found in *Corallium nobile* 2·1 per cent. of carbonate of magnesia, in *Isis hippuris* 6·36 per cent., and in different species of *Serpula* from 1·35 to 7·64 per cent. of carbonate of magnesia; but these genera form exceptions to the general rule.

The Millepores, in like manner, are in great portion made up of carbonates; in some species the mineral matter is almost entirely carbonate of lime, while in others the carbonate of magnesia forms from 16·0 to 19.0 per cent. of the inorganic portion. These millepores are often very abundant, and a

non-magnesian species forms beds on the northern shores of France, which are wrought for burning into lime, while a species containing a large proportion of magnesia is very abundant on the coast of Algiers. Mr. Damour has called attention to the part which these millepores may play in the production of magnesian limestones (*Annales de Chimie et de Physique*, 3d series, vol. xxxii. p. 362.) He however describes them as dissolving readily in acetic acid, which would seem to indicate the absence of dolomite.

The carbonates of lime and magnesia are both much more soluble in carbonated water than the double carbonate, which according to Bischoff, yields little or no magnesia to a solution of carbonic acid. Grandjean, and after him Sandberger, supposes that certain dolomites may have been formed from limestones containing an admixture of carbonate of magnesia, by the action of carbonated waters, which might give rise to dolomite and a soluble bi-carbonate of lime; the iron and other metallic oxyds, being thus concentrated in the residue, their predominance in some dolomites would be explained.—(Liebig and Kopp, *Jahresbericht*, 1848, [Eng. Ed.] vol. ii. p. 501.)

Forchammer, in attempting to illustrate by experiment the formation of dolomite, found that when a solution of bi-carbonate of lime is mingled with sea-water at a boiling heat, the precipitated carbonate of lime carries down with it 12·23 per cent. of carbonate of magnesia; while, if carbonate of soda be mixed with the solution of bi-carbonate, the proportion of magnesian carbonate in the precipitate may rise to 27·93 per cent. The amount of magnesia separated, according to him, appears to augment with the temperature.—(Ibid, vol. ii. p. 575.)

Haidinger long since endeavoured to explain the formation of dolomite and its frequent association with gypsum, by supposing that a reaction between carbonate of lime and sulphate of magnesia might give rise to sulphate of lime and carbonate of magnesia. At ordinary temperatures, it is true, the inverse affinities prevail. Mitscherlich found that a solution of gypsum was completely decomposed after fourteen days contact with carbonate of magnesia, into sulphate of magnesia and carbonate of lime, and the same decomposition takes place

when solution of gypsum is filtered through dolomite. Haidinger however conjectured that at an elevated temperature these affinities might be reversed, and this has been confirmed by Morlot, who found that when a mixture of one equivalent of crystallized sulphate of magnesia and two equivalents of calcareous spar is heated in sealed tubes to 200°. Centigrade, it is completely converted into dolomite and sulphate of lime. (L. & K., *Jahresbericht*, 1848, vol. ii, p. 500.)

Marignac, in like manner, found that at 200°. Centigrade, carbonate of lime with a solution of chlorid of magnesium, slowly gave rise to a double carbonate of lime and magnesia: after six hours the product contained 52·0 per cent. of carbonate of magnesia.—(Favre. *Bull. Soc. Geol. France* [2], vi., p. 318.)

De Sénarmont found in some experiments with mingled solutions of bi-carbonate of magnesia and chlorid of calcium, that at the ordinary temperature, and at temperatures below 100°. Centigrade, a precipitate of pure carbonate of lime separates, provided that the proportion of chlorid of calcium present is more than equivalent to the magnesia in solution; but at 150°. whether the lime-salt be in excess or not, a precipitate of carbonate of magnesia is obtained, with little or no lime. The conditions of this last experiment are similar to that of Marignac, for the carbonate of lime which separates at 100°. is afterwards decomposed at a high temperature by the magnesian chlorid. By double decomposition of carbonate of soda and sulphate of magnesia at from 160°. to 175°. and also by the action of a heat of 155° upon a solution of bi-carbonate of magnesia, De Sénarmont obtained crystallized carbonate of magnesia. (*Ann. de Chim. et Phys.* [3] vol. xxxii. p. 148.)

Taking the experiments of Morlot and the theory of Haidinger as a point of departure, Favre attempts to explain the formation of dolomites. He supposes that eruptions of igneous rocks, at the bottom of a sea 500 or 600 feet in depth, would afford the necessary conditions of heat and pressure; and since the dolomites of the Alps are associated with melaphyres, which are more or less magnesian, he supposes a simultaneous evolution of sulphurous and hydrochloric acids; these, acting

upon the ejected rocks, would produce the magnesian salts necessary for the conversion into dolomites of the adjacent limestones, which, according to him, are interstratified near their base with pyroxenic tufa. These dolomites of the Tyrol are filled with small cavities, while they retain the marks of stratification, and exhibit the remains of corals and encrinites. Favre supposes that they were originally deposited as pure limestones, and in their subsequent conversion into dolomites became cavernous. He conceives that the sea beneath which the volcanic eruptions took place was widely extended, and thus explains the formation of dolomites far away from any intrusive rocks. At the same time, however, he admits that the compact dolomites in many stratified rocks have been originally deposited as such and are not the result of alteration.

To this hypothesis of Favre, Coquand opposes the insufficiency of the erupted masses to heat the water to the temperature required, and he supposes waters, charged with carbonate of magnesia, to have been the agent of the alteration.

The famous theory of Von Buch, based in great part upon these dolomites of the Tyrol, supposes that the dolomization of limestones has been effected by the intervention of some volatile compound of magnesia evolved during the eruption of the porphyries of that region. In support of this hypothesis, Durocher made the experiment of heating together to low redness, in an iron tube, fragments of porous limestone and anhydrous chlorid of magnesium for some hours. The soluble matter being then washed away, the residue effervesced strongly at first with hydrochloric acid; but the action then became feebler, and the residue exhibited transparent crystals under the microscope, which were supposed to be dolomite, but do not appear to have been further examined. (*Philos. Magazine* [4], vol. ii. p. 504.)

To this theory of Von Buch it is to be objected, however, that neither the chlorid nor any other known compound of magnesium, is volatile; and that it is only by the hypothesis of Favre, which supposes the intervention of water, that we can connect the dolomization of limestones, with the eruption of the igneous rocks. Delanoüe and Daubeny have

rejected the hypothesis of Von Buch; and Fournet has since shown that the melaphyres associated with the dolomites of the Tyrol, so far from being intrusive rocks, are themselves stratified rocks, probably of Carboniferous age, metamorphosed *in situ*, and that their alteration was effected long before the deposition of the dolomites, which are of the Jurassic period. Between these metamorphic strata and the dolomites are beds of unaltered Triassic rocks, including the *Muschelkalk*, and a conglomerate which holds rolled pebbles of the subjacent melaphyres. (*Bull. Soc. Geol. de France* [2,] vi., pp. 506–516.)

Delesse has remarked that in many instances limestones which have been regarded as dolomitized by the proximity of igneous rocks, have been rendered crystalline, but contain no magnesia. D lanouë has pointed out examples of a similar error in the crystalline limestones of the calamine mines in Belgium, where in cases of supposed dolomization by contact with igneous rocks, he found no increase in the proportion of magnesia.

The preceding facts show that dolomites have been formed under conditions where the theory of the intervention of volcanic and metamorphic agencies is inadmisible, and we are are to conclude that they have been deposited as magnesian sediments in seas or basins, sometimes lacustrine, from waters which often permitted the development of animal life. The conditions required for the separation of carbonate of magnesia from the sea or other waters, therefore naturally claim our attention, as a first step towards the solution of the problem before us. I have shown, in my last Report, that the precipitate produced by carbonate of soda in a water containing soluble salts of lime and magnesia, consists in great part of carbonate of lime, the magnesian salts being decomposed only after the lime has been removed. Some experiments since made with carbonated waters, serve further to illustrate this geologically important fact.

If to an artificial sea-water, containing besides common salt, chlorids of calcium and magnesium in the proportion of one equivalent of each, we add a solution of bi-carbonate of soda in water saturated with carbonic acid, a gelatinous

precipitate separates, which immediately becomes crystalline. This precipitate being separated after a few hours, washed, dried and submitted to analysis, gave for three successive precipitations from the same liquid, 2·20, 2·00, and 1·23 per cent. of carbonate of magnesia, the remainder being carbonate of lime. It thus appears that the proportion of caronate of magnesia precipitated, diminished as the magnesian salt became predominant in the solution, which now gave no further precipitate with bi-carbonate of soda, but deposited, by evaporation to dryness, a granular residue of hydrated carbonate of magnesia with a little carbonate of lime. From a litre there was thus obtained by evaporation, 4·19 grams of carbonate of magnesia with 0·14 grams of carbonate of lime, while the soluble portion contained in the form of chlorid, 1·176 of magnesia, but no lime.

By boiling for thirty minutes a part of the above solution, from which the first portion (about one-third,) of the lime had been thrown down, there was obtained a precipitate, which for a litre, equalled 0·666 grams of carbonate of lime, and 0·173 of carbonate of magnesia. Another portion of the same solution gave by spontaneous evaporation, for a litre 0·805 of carbonate of lime, without any carbonate of magnesia.

If we employ a more dilute solution of bi-carbonate of soda in the preceding experiment, there is no immediate precipitate of carbonate of lime. A solution was prepared with one litre of water and 29·2 grams (½ eq.) of sea-salt, 13·8 grams (¼ eq.) of chlorid of calcium, and 50·7 grams (½ eq.) of crystallized hydrochlorate of magnesia, with an addition of 10·0 grams of crystallized sulphate of soda. In another litre of water were dissolved 42·0 grams (½ eq.) of bi-carbonate of soda, and a stream of carbonic acid gas was passed through the liquid to saturation. Of this solution 500 cubic centimetres would have been required to decompose the whole of the chlorid of calcium in the first solution, and 200 were gradually added to it with stirring, without producing any visible effect; a third portion of 100 cubic centimetres caused a slight turbidness, which was soon replaced by a crystalline precipitate adhering to the sides of the vessel, and gradually augmenting in quantity. After a repose of forty

hours at 68° F., the precipitate was collected and analyzed. It contained 96·7 per cent of carbonate of lime, and 3·3 of carbonate of magnesia, and equalled 4·304 grams.

The liquid, augmented by the washings of the precipitate, measured 1·400 cubic centimetres ; one-half of this was mixed with 100 cubic centimetres of the solution of bi-carbonate, being the quantity required for the decomposition of the remaining lime-salt. There was no immediate change apparent; but after twenty-four hours a crystalline precipitate was collected, which consisted of carbonate of lime, 97·4 ; carbonate of magnesia, 2·6 ; and equalled 2·288 grams.

The explantion of these facts is found in the power of carbonate of magnesia to decompose the salts of lime, converting them into carbonate. We have already mentioned the observation of Mitscherlich, that carbonate of magnesia, and even dolomite decomposes a solution of gypsum at the ordinary temperature, with formation of sulphate of magnesia ; and Bineau has very recently shown, that if we evaporate solutions containing bi-carbonates of lime and magnesia, in presence of sulphate or muriate of lime, either at the ordinary temperature or by artificial heat, the carbonate of lime is deposited with but a trace of magnesia; from this he concludes that the carbonates of magnesia exhibit with all the soluble salts of lime, the same reactions of incompatibility as the corresponding carbonates of potash and soda. (*Ann. de Chim. et de Phys.*, [3], vol. 51, p. 302.)

Another cause which prevents the precipitation of carbonate of magnesia with the carbonate of lime, even when other salts of lime no longer exist in the solution, is found in the great solubility of bi-carbonate of magnesia as compared with the bi-carbonate of lime. According to Bischoff, carbonate of lime requires for its solution about 1000 parts of water saturated with carbonic acid, and I have found in a solution of bi-carbonate of lime saturated under pressure and then allowed to stand for twenty-four hours, in an imperfectly closed vessel, at a temperature of 60° F., only 0.730 grams of carbonate to a litre, while by adding known portions of carbonate of soda to a solution of chlorid of magnesium in excess, and

then passing a current of carbonic acid through the solution, I have found it easy to obtain solutions containing 10·0 grams of magnesia, equal to 21·0 grams of carbonate of magnesia to a litre of water, or 2·1 per cent.

Bineau found that by by the aid of a current of carbonic acid prolonged for several days, a solution might be obtained, containing 11·2 grams of magnesia, combined with very nearly two equivalents of carbonic acid, in a litre of water. Such solutions by spontaneous evaporation in the open air, lose carbonic acid and deposit carbonate of magnesia, and finally retain only 0·108 grams of magnesia in a litre, with carbonic acid sufficient to form a sesqui-carbonate. Bineau however remarked that in some cases, by the process of evaporation, solutions of sesqui-carbonate were obtained holding 0·17 grams of magnesia to the litre. These super-saturated solutions, when transferred to close vessels, deposited a portion of their magnesia in the form of carbonate. This curious reaction, which depends upon the spontaneous decomposition of the sesqui-carbonate of magnesia into the bi-carbonate and the neutral salt, I have observed in a very remarkable manner in the spontaneous evaporation of carbonated saline mineral waters. A litre of water from the Plantagenet spring was allowed to evaporate in an open porcelain basin in summer until its volume was reduced to one-fifth, during which process, a crystalline crust of carbonates of lime and magnesia, was deposited. The clear solution being poured off, and transferred to a carefully closed bottle, deposited after two or three days, a strongly adherent crystalline crust of hydrated carbonate of magnesia, chiefly upon the lower parts of the vessel. The amount of the precipitate was equal to 0·772 grams of carbonate of magnesia for a litre of the solution, which contained no lime, but abundance of chlorid of magnesium and bi-carbonate of magnesia, after the separation of the carbonate.

When recently precipitated hydrated carbonate of magnesia is added to a solution of bi-carbonate of lime, it immediately dissolves, but the transparent solution soon after becomes troubled from the precipitation of carbonate of lime.

This reaction is precisely analogous to that produced by carbonate of soda, which with bi-carbonate of lime gives a precipitate of neutral carbonate. The carbonate of lime thrown down from solutions of bi-carbonate of magnesia is always nearly pure; and the results of a great variety of experiments undertaken in the hope of producing a double carbonate of lime and magnesia have shown me that when the bi-carbonates of lime and magnesia are dissolved in pure water, in solutions of sea-salt, of chlorid of magnesium, or of carbonate of soda, and evaporated at the ordinary temperature, or heated to 100° F., the carbonate of lime is deposited as in the previous experiments, carrying with it only traces of the magnesian carbonate, which is afterwards separated by elevating the temperature nearly to the boiling-point, or by farther evaporation.

The addition of chlorid of calcium suffices to decompose the magnesian bi-carbonate and to precipitate carbonate of lime even at ordinary temperatures; but when the solution of the two bi-carbonates is boiled, even in the presence of chlorid of calcium, a portion of the magnesian carbonate falls down with the carbonate of lime, as in Forchammer's experiments. In none of these conditions however do we obtain that double carbonate of lime and magnesia, insoluble in acetic acid, which forms the base of the magnesian limestones, and Mr. J. D. Whitney, in commenting upon Morlot's investigations which we have already cited, has well remarked that we have no evidence in these of the formation of a true dolomite.

I have found in the course of my experiments that the introduction of a soluble sulphate modifies in an unsuspected manner the results already described. Mitscherlich found gypsum to be incompatible at ordinary temperatures with carbonate of magnesia, but it is no longer so in the presence of an excess of carbonic acid; in fact, gypsum may be crystallized from a solution of bi-carbonate of magnesia. If to a solution of bi-carbonate of lime, we add a sufficient quantity of sulphate of magnesia, and allow the liquid to evaporate at the ordinary temperature, or by a gentle heat, to a small volume, the whole of the lime is deposited in the form of crystalline gypsum. The same result is obtained when bi-carbonate of lime is added

to a solution containing sea-salt, chlorid of magnesium and sulphates. By evaporation at a temperature of from 90° to 100° F. the gypsum is entirely deposited before the separation of the sea-salt commences, while the bi-carbonate of magnesia remains in solution, and is only separated by evaporation to complete dryness or by ebullition. This reaction may help to explain the frequent association of gypsum and dolomite, as well as the frequent occurrence of both of these in fresh-water formations.

It is evident that with the facts as yet before us, we are not able to determine with certainty the manner in which dolomites have been formed. Bi-carbonate of magnesia may however be produced in two ways: first, by the action of bi-carbonate of lime upon waters containing both sulphates and magnesian salts, gypsum being generated at the same time; and secondly, by the action of bi-carbonate of soda upon magnesian waters from which the lime has previously been separated, either as carbonate by the previous action of bi-carbonate of soda, or by evaporation in the form of sulphate, as takes place during the concentration of sea-water. From these solutions beds of carbonate of magnesia may readily be formed by evaporation in limited basins, precisely as we conceive gypsum and rock-salt to have been deposited; and if we suppose an admixture of carbonate of lime deposited from the alkaline waters or any other source, we have all the elements of dolomite, although not chemically combined as a double salt. H. Ste. Claire Deville, in his beautiful researches on the double carbonates, found that when a mixture of basic carbonate of magnesia with bi-carbonate of soda and water is exposed to a gentle heat, a slow combination ensues, and the mixture is transformed into a mass of small transparent crystals, which are an anhydrous double carbonate of soda and magnesia, insoluble in water,—in fact, a soda-dolomite. (*Ann. de Chim. et Phys.* [3] vol. xxxiii. p. 89).

A similar reaction between the mingled carbonates of lime and magnesia, under conditions not yet understood, may probably result in their gradual transformation into dolomite.

FISH MANURES.

Before describing the results of some enquiries into the value of these manures, and the practicability of introducing their manufacture into Canada, it may be well to explain briefly certain principles which may serve to guide us in the appreciation of the subject. Modern investigations of the chemistry of vegetation have led to a more or less correct understanding of the laws of vegetable nutrition and the theory of manures, and we are all aware how many natural and artificial matters have been proposed as substitutes for the manure of the stable and farm-yard. Foremost among these ranks the Peruvian guano, composed for the most part of the exuviæ of sea-birds, and employed for centuries by the Peruvians as a powerful stimulant to vegetation. This substance owes its value to the phosphoric acid and ammonia which it is capable of affording to the growing plant; the former element being indispensable to the healthy development of vegetation and entering in large proportion into the mineral matter of the cereals, while ammonia furnishes, in a form capable of assimilation, the nitrogen, which with the elements of water and carbonic acid, makes up the organic tissues of plants. Besides these essential principles, plants require sulphuric acid, chlorine, potash, soda, lime, magnesia and oxyd of iron, all of which elements are found in their ashes, and are required for their healthy growth. In a fertile soil all of these ingredients are present, as well as phosphoric acid and ammonia, which last substance is constantly produced by the decay of animal and vegetable matters, and is either at once retained by the soil, which has the power of absorbing a certain portion of it, or is evolved into the air and afterwards dissolved and brought down by the rains to the earth.

Many of the mineral elements of a soil are present in it in an insoluble form, and are only set free by the slow chemical re-actions constantly going on under the influence of air and water. Such is the case with the alkalies, potash and soda, and to a certain extent with the phosphates. Now although there is probably no soil which does not yield by analysis quantities

of all the mineral elements sufficient for many crops, yet by long and uninterrupted tillage the more soluble combinations of these elements may be all taken up, and the land will then require a certain time of repose in order that a store of more soluble matters may be formed. Hence the utility of fallows.

In my analyses of the soils of the Richelieu valley, in the Report for 1850, pp. 79–90, I have shown, by comparing the virgin soils with those exhausted by continued crops of wheat during fifty years, that the proportions of phosphoric acid and magnesia, elements which are contained in large quantities in this grain, have been greatly diminished, but the soil still contains as much phosphate as it has lost, and this only requires to be rendered soluble in order to be available to vegetation.

In forests and untilled lands the conditions of a healthy vegetable growth are seldom wanting; the soil affords in sufficient quantity all the chemical elements required, while the leaves and seeds which annually fall and decay, give back to the earth a great proportion of the elements which it has yielded. In this way the only loss of mineral matter is that which remains stored up in the growing wood or is removed by waters from the soil. Far different is the case in cultivated fields, since in the shape of corn, of fat cattle, and the products of the dairy, we remove from the soil its phosphates, alkalies and nitrogen, and send them to foreign markets. The effect of tillage becomes doubly exhaustive when by artificial means we stimulate vegetation without furnishing all the materials required for the growing plants. Such is the effect of many special manures, which while they supply certain elements, enable the plants to remove the others more rapidly from the soil. A partial exhaustion of the soil results likewise from repeated crops of the same kind; for the elements of which the cereals require the largest quantity are taken in smaller proportions by green crops, and reciprocally, so that by judicious alternations the balance between the different mineral ingredients of the soil is preserved.

One of the great problems in scientific agriculture is to supply to the soil the ammonia and the mineral matters ne-

cessary to support an abundant vegetation, and to obtain from various sources these different elements at prices which will permit of their being economically made use of. Nowhere but in the manure of the s able and farm-yard can we find combined all the fertilizing elements required, but several of them may be very cheaply procured. Thus lime and magnesia are abundant in the shape of marl and limestones; soda is readily obtained, together with chlorine, in common salt; while gypsum or plaster of Paris supplies at a low price both sulphuric acid and lime. Potash when wanting may be supplied to the soil by wood-ashes, but phosphoric acid and ammonia are less easily obtained and command higher prices.

An abundant supply of phosphate of lime is found in bones, which when dried contain from 50·0 to 60·0 p. c. of mineral matter, consisting of phosphate of lime, with a little carbonate, and small portions of salts of magnesia and soda. The remainder is organic matter, which is destroyed when the bones are burned. This phosphate of lime of bones contains 46·0 per cent of phosphoric acid, and the refuse bone-black of the sugar-refiners usually affords about 32·0 per cent. of the acid. The different guanos also contain large amounts of phosphoric acid, and that known as Columbian guano is principally phosphate of lime. Various deposits of mineral phosphate of lime have of late attracted the attention of scientific agriculturists. I may mention in this connection the crystalline phosphate of lime or apatite of our Laurentian limestones, and the phosphatic nodules found in different parts of the Lower Silurian strata of Canada and described in previous Reports.

These mineral phosphates are in such a state of aggregation, that it is necessary to decompose them by sulphuric acid before applying them to the soil. The same process is also very often applied to bones; for this end the phosphate of lime in powder is to be mingled with nearly two-thirds its weight of sulphuric acid, which converts two-thirds of the lime into sulphate, and leaves the remainder combined with the phosphoric acid as a soluble super-phosphate. In this way, the phosphoric acid may be applied to the soil in a much more divided state, and its efficiency is thereby greatly increased.

Even in its soluble form however, the phosphoric acid is at once neutralized by the basic oxyds in the soil, and Mr. Paul Thenard has lately shown that ordinary phosphate of lime, when dissolved in carbonic-acid water, is decomposed by digestion with earth, insoluble phosphates of iron and alumina being formed, which are again slowly decomposed by the somewhat soluble silicate of lime present in the soil, and transformed into silicates with formation of phosphate of lime. It is probable that alkaline silicates may also play a similar part in the soil. These considerations show that the superior value of soluble phosphate of lime as a manure, depends solely upon its greater subdivision. A portion of the phosphoric acid in Peruvian guano exists in a soluble condition as phosphate of ammonia.

With regard to the nitrogen in manures, it may exist in the form of ammoniacal salts, or combined in organic matters which evolve ammonia by their slow decay. The ammonia which the latter are capable of thus yielding, is designated as potential or possible ammonia, as distinguished from the ammonia of the ammoniacal salts, which is generally soluble in water, and is at once disengaged when these matters are mingled with potash or quick-lime. Such is the sulphate of ammonia, which is prepared on a large scale from the alkaline liquid condensed in the manufacture of coal-gas. In Peruvian guano a large amount of the nitrogen is present as a salt of ammonia, and the remainder chiefly as uric acid, a substance which readily decomposes, and produces a great deal of ammonia. In fact, this decomposition takes place spontaneously, with so much rapidity, that the best guanos may, it is said, lose more than one-fifth of their nitrogen in the form of ammonia in a few months' time, if exposed to a moist atmosphere.

Other manures, however, contain nitrogen in combinations which undergo decomposition less readily than uric acid. Thus unburned bones yield from six to seven per cent. of ammonia, and dried blood, fifteen or sixteen per cent., while woolen rags and leather yield about as large a quantity. In estimating the value of such matters as manures, the difference in the facility with which they enter into decom-

position, must be taken into account. Thus if too large quantities of guano are applied to the soil, a portion of the ammonia may be volatilized and lost, while with leather and wool the decay is so slow, that these materials have but little immediate effect as manures. The nitrogen of blood and flesh is converted into ammonia with so much ease, that it may be considered almost as available for the purpose of a manure as that which is contained in ammoniacal salts.

Attempts have been made to fix the money value of the ammonia and the phosphates in manures, and thus to enable us from the results of analysis, to estimate the value of any fertilizer containing these elements. This was I believe first suggested a few years since, by an eminent agricultural chemist of Saxony, Dr. Stöckhardt, and has been adopted by the scientific agriculturists of Great Britain, France, and the United States. These values vary of course very much for different countries; but I shall avail myself of the calculations made by Prof. S. W. Johnson of New Haven, Connecticut, which are based on the prices of manures in the United States in 1857. In order to fix the value of phosphoric acid in its insoluble combinations, he has taken the market prices of Columbian guano, and the refuse bone-ash of the sugar refiners, which contain respectively about 40 and 32 per cent. of phosphoric acid, and from these he deduces as a mean 4½ cents the pound as the value of phosphoric acid when present in the form of phosphate of lime. This would give $1.44 as the value of 100 pounds of bone-ash, and $1.60 for the same amount of the guano, while they are sold for $30 and $35 the ton.

The value of soluble phosphoric acid has been fixed by Dr. Völcker in England, and by Stöckhardt in Saxony, at 12½ cents the pound. This evaluation is based upon the market price of the commercial super-phosphates of lime. Mr. Way, of the Royal Agricultural Society, however, estimates the value of phosphoric acid in its soluble combination at only 10½ cents the pound; and Mr. Johnson, although adopting the higher price, regards it as above the true value.

In order to fix the real value of ammonia, Prof. Johnson deducts from the price of Peruvian guano, at $65 the ton, the

value of the phosphoric acid which it contains, and thus arrives at 14 cents the pound for the price of the available ammonia present. This kind of guano, however, now commands a price conderably above that which serves for the basis of the above calculation; and both Völcker and Stöckhardt fix the value of ammonia at 20 cents the pound. The price of potash as a manure is estimated by Mr. Johnson at 4 cents the pound; but this alkali rarely enters to any considerable extent into any concentrated manures, and may therefore be neglected in estimates of their value.

The use of fish as a manure has long been known; on the shores of Scotland, Cornwall, Brittany, some parts of the United States, and on our own sea-coasts, the offal from fisheries, as well as certain bony fishes of little value for food, are applied to the soil with great benefit. The idea of converting these materials into a portable manure was however I believe first carried into effect in France by Mr. Démolon, who seven or eight years since, erected establishments for this object on the coast of Brittany and in Newfoundland. For the details of this manufacture I am indebted to the *Chimie Industrielle* of Payen. Concarneau, in the department of Finisterre, is a small town whose inhabitants are employed in fishing for sardines, and it is the refuse of this fishery which is employed in the manufacture of manure. The offal is placed in large coppers and heated by steam until thoroughly cooked, after which it is submitted to pressure, which extracts the water and oil. The pressed mass is then rasped, dried in a current of hot air, and ground to powder. 100 parts of the recent offal yield on an average 22 parts of the powder, besides from 2 to 2½ parts of oil. The manufactory of Concarneau employs six men and ten boys, and is able to work up daily eighteen or twenty tons of fish, and produce from four to five tons of the powdered manure.

This manure contains, according to an average of several analyses, 80·0 per cent. of organic matters, and 14·1 per cent. of phosphates of lime and magnesia, besides some common salt, a little carbonate of lime, small portions of sulphate and carbonate of ammonia, and only 1·0 per cent of water. The

nitrogen of this manure, which is almost wholly in the form of organic matters, corresponds to 14·5 per cent of ammonia, and we may estimate the phosporic acid, which is here present in an insoluble form, at 7·0 per cent. If we calculate the value of this manure according to the rules above laid down, we shall have as follows for 100 pounds:—

Ammonia,—14½ pounds, at 14 cents,.........	$2.03
Phosphoric Acid,—7 pounds, at 4½ cents,.....	0.31½
	$2.34½

This is equal to $47 the ton of 2000 pounds; the manufactured product of Concarneau, however, according to Payen, is sold in the nearest shipping ports at 20 francs the 100 kilogrammes, (equal to 220 pounds), which, counting the franc at $0.20, is equivalent only to $1.81 the 100 pounds, or a little over $37 the ton. This however was in 1854, since which time the price of manures has probably increased.

Mr. Démolon in company with his brother, has also according to Payen, erected a large establishment for the manufacture of this manure on the coast of Newfoundland, at Kerpon, near the eastern entrance of the Strait of Bellisle, in a harbor which is greatly resorted to by the vessels engaged in the cod-fishery. This manufactory, now in successful operatiod, is able to produce 8,000 or 10,000 tons of manure annually. Payen estimates the total yearly produce of the cod-fisheries of the North American coast to be equal to about 1,500,000 tons of fresh fish; of this, one-half is refuse, and is thrown into the sea or left to decay on the shore, while if treated by the process of Démolon, it would yield more than 150,000 tons of a manure nearly equal in value to the guano of the Peruvian islands, which now furnish annually from 300,000 to 400,000 tons. If to the manure which might be obtained from the cod-fisheries of the Lower Provinces, we add that of many other great fisheries, we are surprised at the immense resources for agriculture now neglected, which may be drawn at a little expense from the sea, and even from the otherwise worthless refuse of another industry. To this may

be added vast quantities of other fish, which at certain seasons and on some coasts are so abundant that they are even taken for the express purpose of spreading upon the adjacent lands, and which would greatly extend the resources of this new manufacture. The oil, whose extraction is made an object of economic importance in the fabrication of manure from sardines in France, exists in but very small quantities in the cod, but in the herring it equals 10 per cent. of the recent fish, and in some other species rises to 3·0 and 4·0 per cent.

Mr. Duncan Bruce of Gaspé has lately been endeavoring to introduce the manufacture of fish-manure into Canada; but he has conceived the idea of combining the fish-offal with a large amount of calcined shale, under the impression that the manure thus prepared will have the effect of driving away insects from the plants to which it is applied. He employs a black bituminous shale from Port Daniel, and distilling this at a red heat, passes the disengaged vapours into a vat containing the fish, which by a gentle and continued heat, have been reduced to a pulpy mass. The calcined shale is then ground to powder and mingled with the fish, and the whole dried. Experiments made with this manure appear to have given very satisfactory results, and it is said to have had the effect of driving away insects when applied to growing crops, a result which may be due to the small amount of bituminous matter in the products of the distillation of the shale, rather than to the admixture of the calcined residue. Coal-tar is known to be an efficient agent for the destruction of insects, and in a recent number of the journal, *Le Cosmos*, it is stated that simply painting the wood-work of the inside of green-houses with coal-tar has the effect of expelling from them all noxious insects. Mr. Bruce caused several analyses of this shale to be made by Dr. Reid of New York, from which it appears that different specimens contain from 2·0 to 26·0 per cent. of carbonate of lime, besides from 1·4 to 2·0 per cent. of gypsum, 2·0 per cent. of iron pyrites, and from 4·5 to 6·7 per cent. of carbon remaining after distillation. The amount of volatile matter, described by Dr. Reid as consisting of water, naphtha and ammonia, was

found by him in two different samples to equal only 3·5 per cent., of which a large proportion is probably water.

I have examined two specimens of manure prepared by Mr. Bruce from the fish commonly known as the menhadden (*Alosa menhadden*). No. 1 was made with the Port Daniel shale, as before described; while for No. 2, this was replaced by a mixture of clay and saw-dust, which was distilled like the shale, the volatile products being added to the decomposing fish. The oil which rose to the surface of the liquid mass had been separated from the second preparation, but remained mingled with the first. Both of these specimens were in the form of a black granular mass, moist, cohering under pressure, and having a very fishy odour. A proximate analysis of these manures was first effected by exposing a weighed portion to a temperature of 200° F. till it no longer lost weight, and then calcining the residue, from which the carbonaceous residue very readily burned away. The oil in the first specimen was obtained by digesting a second portion, previously dried, with ether, so long as anything was taken up. The solution by evaporation left the oil, whose weight was deducted from the loss by ignition. The portion of oil remaining in the second sample was not determined.

	I.	II.
Animal matters and carbon,	23·7	21·0
Oil,	6·6	
Water,	13·5	21·8
Earthy matters,	56·2	57·2
	100·0	100·0

The residue of the calcination was digested with hydrochloric acid, which dissolved the phosphate of lime from the fish-bones, together with portions of lime, magnesia, alumina, and oxyd of iron, derived from the shale and clay. The solution from No. 1 contained, moreover, a considerable portion of sulphate from the gypsum of the shale. Small quantities of common salt were also removed by water from the calcined residues. The dissolved phosphoric acid, lime, and magnesia were separated by precipitating the phosphoric acid in combin-

ation with peroxyd of iron, from a boiling acetic solution, and were determined according to the method of Fresenius. The nitrogen of the organic matter was estimated by the direct method of burning a portion of the dried substance with soda-lime, and weighing the disengaged ammonia as ammonio-chlorid of platinum. The results were as follows for a hundred parts:—

	I.	II.
Phosphoric acid,	3·40	3·99
Sulphuric acid,	2·16	·15
Lime,	5·90	4·44
Magnesia,	1·20	1·15
Ammonia,	3·76	2·60

If we calculate the value of the first specimen according to the rules already laid down, we have as follows for 100 pounds:—

Phosphoric acid, $3\frac{4}{10}$ pounds at $4\frac{1}{2}$ cents,	$0·153
Ammonia, $3\frac{3}{4}$ pounds at 14 cents,	0·525
	$0·678

At 68 cents the 100 pounds, this manure would be worth $13.60 the ton. The sulphuric acid is of small value, corresponding to 80 pounds of plaster of Paris to the ton, and we do not take it into the calculation. The somewhat larger amount of phosphoric acid in the second specimen, is probably derived in part from the ashes of the saw-dust, and in part from the clay. The value of this manure would be $10·88 the ton.

In order to arrive at the real value of the animal portion of this manure after the removal of the oil, we may suppose, since Dr. Reid obtained from the shales from 4·5 to 7·6 per cent. of fixed carbon, that with the 56·2 parts of calcined residue, there were originally 3.7 parts of carbon derived from the shales. This deducted from 23·7 parts leaves 20·0 of nitrogenized animal matter in 100 parts of the manure, yielding 3·76 parts, or 18·8 per cent. of ammonia. This matter consists chiefly of muscular and gelatinous tissues, and Payen obtained from the dried muscle of the codfish, 16·8 per cent. of nitrogen,

equal to 20·4 of ammonia. The 3·4 parts of phosphoric acid in the manure will correspond to 7·4 of bone-phosphate, and if to this we add for moisture, impurities, etc., 2·6 parts, = 30·0 in all, we should have for 100 pounds of the fish when freed from oil and dried, the following quantities of ammonia and phosphoric acid :—

Ammonia,—12½ pounds at 14 cents,	$1·75
Phosphoric acid,—11¼ pounds at 4½ cents,	0·51
	$2·26

The matter thus prepared would have a value of $45.20 the ton, agreeing closely with that which we have calculated for the manure manufactured from sardines in France, in which the quantity of ammonia is somewhat greater, and the phosphoric acid less, giving it a value of $47 the ton.

Prof. George H. Cook of New Jersey, in an analysis of the menhadden, obtained from 100 parts of the dried fish, 16·7 parts of oil, besides 61·6 of azotized matters yielding 9·28 parts of ammonia, and 21·7 of inorganic matters, etc., containing 7·78 of phosphoric acid.* If we deduct the oil, we shall have for 100 parts of the fish, according to this analysis, 11·2 of ammonia, and 9·3 of phosphoric acid.

By comparing these figures with the results calculated for the animal portion of Mr. Bruce's manures, we find :—

	Ammonia.	Phosphoric acid.
Manure from sardines (Payen),	14·5	7·0
Dried menhadden (Cooke),	11·2	9·3
Manure by Mr. Bruce	3·75	3·4
" " (excluding shale),	12·5	11·3

The proportion of phosphates is of course greater in the more bony fishes. In the manure of Mr. Bruce there are doubtless small amounts of phosphoric acid and ammonia, derived from the shale and the products of its distillation; but these do not however warrant the introduction of an inert material which reduces more than two-thirds the commercial value

* Report of the Geological Survey of New Jersey for 1856, p. 63.

of the manure. The results which we have given clearly show that by the application of a process similar to that now applied in France and in Newfoundland, which consists in cooking the fish, pressing it to extract the oil and water, drying by artificial heat, and grinding it to powder, it is easy to prepare a concentrated portable manure, whose value, as a source of phosphoric acid and ammonia, will be in round numbers, about $40 the ton.

We can scarcely doubt that by the application of this process a new source of profit may be found in the fisheries of the Gulf, which will not only render us independent of foreign guano, now brought into the Province to some extent, but will enable us to export large quantities of a most valuable concentrated manure, at prices which will be found remunerative.

I have the honor to be,

Sir,

Your most obedient servant,

T. STERRY HUNT.

REPORT,

FOR THE YEAR 1857,

OF

LIEUT. E. D. ASHE, R.N., F.R.A.S.,

ADDRESSED TO

SIR W. E. LOGAN, F.R.S.,

DIRECTOR OF THE GEOLOGICAL SURVEY OF CANADA.

ON THE LONGITUDE OF SOME OF THE PRINCIPAL PLACES IN CANADA, AS DETERMINED BY ELECTRIC TELEGRAPH IN THE YEARS 1856-57.

QUEBEC, 20th January, 1858.

SIR,

In the month of October, 1856, at your request I left Quebec for Montreal, in order to determine by electric telegraph the longitude of that city. On my arrival, the first object was to procure a suitable place, not far from the telegraph wire, and permission was given to make use of the top of the Exchange.

The transit instrument was placed upon a stack of chimnies, and a temporary canvas cover erected to protect the instrument from the wind. On the 28th October the transit instrument was in the meridian, the telegraph wire was led up to the top of the house, and a message sent to Quebec to be ready at 7 P.M. The night was fine and clear, and we commenced by giving a signal to look out when a star entered the field of the

telescope, and as it passed each wire a single dot was sent along the line to Quebec. The assistant, Mr. Heatley, on the signal being given to look out, listened attentively to these dots and to the tick of the sidereal clock, and registered the fraction of a second; by these means the observations at Montreal were noted down with all the ease and facility that could have been attained in a properly fitted observatory, instead of the temporary arrangement we had on the top of a house.

From the operators not understanding some technical expressions, and from the novelty of the transaction, many stars were lost; but considering that it was a first trial we had every reason to expect that we should finally succeed.

On the following night we were again connected by the telegraph wire, but after sending a few stars a great disagreement was found to exist between this and the preceding night's work. On my taking observations to determine the errors of the instrument, I found that it had moved considerably out of the meridian; and subsequently I discovered that the passing of a cart, even at the distance of two streets, put the whole chimney in motion; for this there was no remedy, and the idea of succeeding with the present arrangement was hopeless.

Having to return to Quebec, I left on the 2nd November, with the knowledge taught by experience that a transit instrument placed on the top of a house could only give doubtful observations, which were worse than useless.

On the 29th December I left Quebec for Toronto, and on my arrival took up my quarters with my friend Professor Kingston of the Magnetic Observatory. Here there was every convenience, a small transit instrument in position, and a sidereal clock. The observations for time were under the superintendence of Professor Kingston. The distance of the Observatory from the Telegraph Office is, I should think, about two miles, and the work of leading the wire through the town and into the Observatory presented many difficulties—one, the ground being frozen hard could not be opened for sinking the posts, and another, the interference with private property; but by the hearty co-operation of the

Superintendent of the Telegraph Office, Mr. Dwight, and by some contrivance, these difficulties were surmounted.

The cloudy state of the atmosphere prevented our working until the 17th January, which was fair for observations. As our object was to determine the time by the face of our respective clocks at the same instant, thirty dots were sent at intervals of a second in each minute, so that if the clocks were not beating together, the fraction of a second that one clock was after the other might be guessed at. The fraction being known, the second, minute, and hour are sent, and consequently the readings of the two clocks are known at the same moment.

The errors of the clocks were obtained by observations of many stars on the same night, and the errors applied to the respective clocks; the true difference of time between Quebec and Toronto was thus known, and hence the longitude. *See Table.*

On the 5th February I left Quebec for Kingston, and on my arrival was offered a home and every assistance by Dr. Yates. The site which I selected for the temporary Observatory is situated in a cross street between Earl street and Barrie street. Two large blocks of limestone were brought and placed in the corner of a yard, and some planks about six feet long were fixed around them, covering in a space about eight feet square. This was also some distance from the Telegraph Office, but by taking advantage of an old fence and of an occasional tree, the wire was brought to the Observatory without much difficulty.

My past experience had taught me to avoid the tops of houses, and to select the solid earth and solid rock for the support of my transit instrument. Still I had another lesson to learn. This neighborhood was infested with boys, who when they saw a light shining through the cracks of the boards, commenced throwing stones with a determination and precision worthy of a better cause; and some of the few clear nights that occurred in this month were lost in consequence of boys' love of mischief. I first tried mild entreaties and then severe threatenings; they laughed at the former, and made faces at the latter. I then procured the service of the police, who

partly succeeded in keeping the boys from further interference with my duties.

On the night of the 20th February, all being ready, and the weather favorable, we made arrangements for sending signals to Quebec. I found that the method adopted at Montreal, of sending a signal to the Observatory at Quebec each time a star passed the wire of the telescope, involved the necessity of employing a telegraph operator for some hours; but by merely exchanging the time, the operator was not required for a longer period than half-an-hour; consequently, in this case, we sent thirteen taps, at intervals of twenty seconds, from Kingston to Quebec, from a mean solar chronometer. As a sidereal clock gains one second on the mean solar chronometer in six minutes, Quebec listened for and marked down the second of the sidereal clock which was co-incident with the signal sent from Kingston, and consequently without any guess-work, had the fraction of a second. Quebec then sent similar signals from the sidereal clock, and Kingston listened for and marked down the second which was co-incident with the signal sent from Quebec; in this way was the difference between the two places ascertained to the hundredth part of a second. I conceive that signals sent from one end of the line by *mean time* and from the other end by *sidereal time* ensure the most satisfactory results. Although the observations for time were not very satisfactory, still from the severity of the weather, and the nuisance above alluded to, I resolved not to stay any longer for further trials, but left for Montreal on the 30th. On my arrival, I accompanied you, and we reconnoitred in the neighbourhood of Viger square, where we were glad to find that there appeared to be a scarcity of boys, and those that did heave in sight were perfectly tame. The gardener's tool-house, in Viger square, appeared well suited to our purpose, and by placing a large block of limestone, on a solid basis built beneath it, we had in perfection the principal requisite for the support of a transit instrument—that of fixity.

In order that I might avail myself of every opportunity of taking observations, I took up my residence there, and although great cold was experienced, nevertheless the advantage of being close to my work, far more than compensated for the severity of the weather.

The night of the 12th March was clear, the instrument firmly fixed and well adjusted, and signals were sent to and from Quebec. Although the electric current was weak, and the signals at the Montreal end of the line difficult to be heard, still the results were most satisfactory, and I left on the following morning for Quebec.

Chicago being placed on some charts, in a longitude differing by upwards of forty miles from that on another, it was of the greatest consequence before making a map of Canada, that the right position of Chicago should be ascertained. I therefore with that view, left Quebec early in the month of April, for this renowned city, and on my arrival, called on Lieut.-Col. Graham, U. S. A., and stated the object of my visit. He offered and gave me his valuable assistance, and obliged me by taking charge of the operations at one end of the line; after an observatory was erected, my transit instrument in position, and the telegraph authorities spoken to, I hurried back to Quebec, and found that they had succeeded on one night in sending signals; but in consequence of the weather not being very favorable at Chicago, we were again in communication on the night of the 15th May.

The electric current was transmtted *via* Toledo, Cleveland, Buffalo, Toronto and Montreal, a distance of 1210 miles, by one entire connection between the two extreme stations, and without any intermediate repetition, and yet all the signals were heard distinctly at either end of the line; the signal occupied only ·08 of a second in passing along that distance.

On the 24th July, I left Quebec for Windsor, and my past experience enabled me soon to select a spot suitable for the transit instrument, around which a covering of boards was put up; on the night of the 15th August, we succeeded in sending signals to Quebec; but unfortunately the sky became cloudy, and I was unable to get satisfactory observations for

the local time. However, on the 18th, the signals and observations for time were most complete.

On the 19th, I left Windsor for Collingwood, and on my arrival, I found rock and quietness in the yard of Mr. Armstrong's house, where I was stopping, The instrument was in position and the night favorable, on the 1st September, and satisfactory signals were exchanged. I left on the following day for Quebec.

It was now most important that the longitude of Quebec should be determined with the utmost possible accuracy. I had formerly by electric signals on one night from Fredericton, N. B., obtained, by the kindness and assistance of Doctors Toldervy and Jack, the position of the Quebec Observatory, but on that night observations for our local time could not be taken, and we had to trust to the observations taken on the previous night and to the good character of the sidereal clock.

If we had been able to get the difference of longitude between Fredericton and Quebec, the position of the Quebec Observatory would have been quite certain, as the longitude of the former had been obtained by frequent signals on many nights with Cambridge, which by interchange of several hundred chronometers with Greenwich, is supposed to have its meridional difference of longitude ascertained with all the accuracy possible short of that to be arrived at by the transatlantic cable.

We were unable to again get telegraphic communication with Fredericton on account of the submerged cable at Cape Rouge being broken; but Professor W. C. Bond, of Cambridge Observatory, offered in the kindest manner possible to send and receive signals to and from Quebec; on the 21st September and 9th October, the communications between the Observatories of Cambridge and Quebec, were completely successful, and the longitude of Quebec, as well as those places already referred to, finally settled.

The longitude of this Observatory as obtained by telegraphic signals, and the longitude published on the Admiralty Charts, differ by no less than fourteen seconds of time, and the other

places whose positions have been determined in a similar manner have a still greater difference.

On the 29th October, I left Quebec for Ottawa, and on my arrival put up at Mr. Doran's boarding house and went in quest of a site for the transit instrument. On Barrack Hill there were several blocks of limestone, around one of which I built a little Observatory and had the telegraph wire brought there. The night of the 14th November was beautifully clear, and the result of our night's work most satisfactory.

In conclusion I may say that the ease and accuracy with which the position of a place can now be fixed by means of the electric telegraph renders it imperative that all those places which can avail themselves of the use of the telegraph line, should have their longitudes determined at once, in order that a correct map of Canada may be produced.

Subjoined I send you an abstract of the observations made.

I have the honor to be,

Sir,

Your most obedient servant,

E. D. ASHE.

Abstract of the Telegraphic Observations determining the Longitudes of several places in North America, by LIEUT. E. D. ASHE, R. N.

QUEBEC, 21st Sept., 1857.

The place of observation was the Observatory in Mann's Bastion, Citadel.

	H.	m.	s.
By the signals sent from Quebec to Cambridge, the difference of longitude is shown to be............................	0	0	18·27
And by the signals from Cambridge to Quebec	0	0	18·25
Mean difference of longitude by the work of the 21st September,	0	0	18·26
Again on the 9th October:—			
By the signals sent from Quebec to Cambridge, &c.	0	0	18·44
By the signals from Cambridge to Quebec	0	0	18·33
Mean difference of longitude by the work of the 9th October ..	0	0	18·38
Mean of both nights' work:—			
Quebec Observatory west of Cambridge Observatory,..........	0	0	18·32
Longitude of Cambridge west of Greenwich, as communicated by Professor W. C. Bond........................	4	44	30·70
Longitude of Quebec Observatory..........................	4	44	49·02

TORONTO, 21st January, 1857.

The place of observation was the Magnetic Observatory.

	H.	m.	s.
By the signals sent from Quebec, Toronto is west of Quebec...	0	32	44·51
By the signals from Toronto, " " " ...	0	32	44·31
Mean difference of longitude	0	32	44·41
Longitude of Quebec	4	44	49.02
Longitude of Toronto Magnetic Observatory.................	5	17	33·43

KINGSTON, 28th February, 1857.

The place of observation was the new Court-house.

	H.	m.	s.
By the signals sent from Quebec, Kingston is west of Quebec..	0	21	05·60
By the signals from Kingston, " " " ..	0	21	05·39
Mean difference of longitude	0	21	05·50
Longitude of Quebec..	4	44	49·02
Longitude of Kingston..	5	5	54·52

MONTREAL, 12th March, 1857.

The place of observation was in Viger Square, 650 feet west of Capt. Bayfield's station on Gate Island.

	H.	m.	s.
By the signals sent from Quebec, Montreal is west of Quebec ..	0	9	23·01
By the signals sent from Montreal, " " " ..	0	9	22·38
Mean difference of longitude	0	9	22·70
Longitude of Quebec	4	44	49·02
Longitude of Montreal..	4	54	11·72

CHICAGO, 15th May, 1857.

The place of observation was in the play-ground of the School situated to the northward of the Roman Catholic Church, Huron Street.

	H.	m.	s.
By the signals sent from Quebec, Chicago is west of Quebec ..	1	5	41·44
By the signals sent from Chicago, " " " ..	1	5	41·60
Mean difference of longitude..................................	1	5	41·52
Longitude of Quebec	4	44	49·02
Longitude of Chicago	5	50	30·54

WINDSOR, 18th August, 1857.

The place of observation was in the yard of Mr. Sholand in Goyeau Street, about fifty yards to the westward of the new English Church, and twenty yards to the westward of the Court-house.

	H.	m.	s.
By the signals sent from Quebec, Windsor is west of Quebec..	0	47	19·04
By the signals sent from Windsor, " " " ..	0	47	18·97
Mean difference of longitude..................................	0	47	19·00
Longitude of Quebec..................................	4	44	49·02
Longitude of Windsor..................................	5	32	08.02

COLLINGWOOD, 1st September, 1857.

The place of observation was the Railway terminus.

	H.	m.	s.
By the signals sent from Quebec, Collingwood is west of Quebec	0	36	01·43
By the signals sent from Collingwood, " " "	0	36	01·59
Mean difference of longitude..................................	0	36	01·51
Longitude of Quebec..................................	4	44	49·02
Longitude of Collingwood..................................	5	20	50.53

OTTAWA, 14th November, 1857.

The place of observation was 120 yards east of the Flag-staff on Barrack Hill.

	H.	m.	s.
By the signals sent from Quebec, Ottawa is west of Quebec...	0	17	59·24
By the signals sent from Ottawa, " " " ...	0	17	59·30
Mean difference of longitude..................................	0	17	59·27
Longitude of Quebec..................................	4	44	49·02
Longitude of Ottawa..................................	5	2	48·29